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ABSTRACT

The paper, part of an all-day workshop, reviews research and theory on left-right hemisphere information processing and psychophysiological models on the functional organization of the brain. Hemisphericity is considered in terms of language, cognitive styles, role in education, verbal and non-verbal processing, affective concomitants, and communication between the hemispheres. EEG (elctroencephalography) correlates of cognitive and affective states are discussed and patterns are classified according to delta, theta, alpha, and beta, categories. A psycho-physiological model of problem solving is proposed which associates hemispheric and EEG correlates to four stages of creative thinking (preparation, incubation, illumination, and verification). Training approaches on problem solving are offered, beginning with relaxation techniques and including profile analysis determining learning styles and instructional method. Educational implications are seen to include the importance of identifying the student's neurologically based learning style, of providing more opportunities to exercise the intuitive approach to problem solving, and of encouraging a relaxed classroom environment. (CL)

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The Left-Right Hemisphere Model for Information Processing

Possible Implications for Education

Ron Rubenzer

Evaluation and Placement Center for the Gifted

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Running Head: The Left-Right Hemisphere Model

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Abstract

By generating empirically testable physiological models of cognition and affect, the understanding and facilitation of learning and problem solving can be advanced. A review of the representative research and theoretical literature on left-right hemisphere information processing and psychophysiolocial models regarding the functional organization of the brain is presented in this paper. The major roles of the left-right hemispheric processing modes in language, learning, perception, creativity, and affect are discussed. The educational implications of hemispheric studies are addressed with respect to future research and practical classroom applications. A Psychophysiological model for problem solving is presented.

The Left-Right Hemisphere Model of Information Processing: Possible Implications for Education

"Man ascends by discovering the fullness of his own gifts . . . what he creates on the way are monuments to the stages in his understanding of nature and of self." (Bronowski, 1973, p. 24). Jacob Bronowski's eloquently expressed statement on the "ascent of man" appears to be directly related to a most important direction in education, namely the study of the psychological processes which underlie intellective functioning. The necessity for attempting to more fully understand, and thus perhaps more directly enhance learning and creativity has been considered by Guilford (1975) to be central to education, as indicated when he stated, "I have advocated, and I still do, that the student be taught about the nature of his own intellectual resources, so that he may gain more control over them" (p. 120).

Two Methods of Investigation of Cognitive Functioning

Factor Analysis

Guilford's structure of the intellect. In order to discover more about these "intellectual resources" Guilford (1968) developed the structure of intellect (SI) theory and model. Guilford's SI theory and model have greatly advanced our ability to meaningfully decipher the enigma known as intellect into a comprehensible system. Essentially, Guilford employed the multiple factor analysis technique (developed by L.L. Thurstone in 1948) to find

"common factors" or "primary mental abilities" (Thurstone, 1948) of intellectual functioning. Basically, Guilford administered an extensive array of tests designed to cover relevant known or theorized areas of ability, and then by using the statistical technique called factor analysis he reasoned that if two or more tests were intercorrelated (related), a common trait or primary mental ability was being measured. According to his initial analyses, 120 factors were identified (Guilford, 1968). Thus, a hypothetical model of intellectual functioning was developed based on inferences made concerning the clustering patterns of Guilford's test results. Such test results are termed "standardized and objective samples of observable behavior" (Anastasi, 1968, p. 21). According to Anastasi (1968) this method of obtaining "samples of observable behavior" through testing is open to many biasing influences such as the reliability and validity of the test instruments, the level of expertise of the test administrators, and subject variables such as test anxiety, attitude, fatigue, ethnic and cultural background, and meta learning habits (e.g., ability to attend to appropriate tasks, etc.) (Tannenbaum, 1977). A method for investigating cognitive functioning which appears to circumvent some of the conventional biasing factors (subject fatigue, background, attitude, test reliability and validity) involved in paper-pencil testing is the psychophysiological method (psychophysiology is"the study of physiology in relation to the mind and its processes")(Hinsie & Campbell, 1960, p. 610).

The Psychophysiological Method of Investigation

"The science of subjective experience" (Davidson & Krippner, 1971). The psychophysiological approach to the analysis of mental functioning is gaining great impetus (Brandwein & Ornstein, 1977; Brown, 1977; Gowan, 1974; Green, 1969; Mulholland, 1971; Ornstein, 1978; Samples, 1975; Schwartz, 1976) and may very well reflect a new evolutionary phase in the development of psychological and educational measurement. Many psychological states which were not conventionally observable and consequently could not be scientifically studied are now entering the realm of empirical analysis. Davidson and Krippner (1971) have coined the term for this psychophysiological method of research the "science of subjective experience." In describing this "science of subjective experience" they state:

> Through the use of converging operations (recurrent specific physiological patterns) we can obtain objective evidence for the existence of hypothetically constructed psychological states. That is, if we ask a subject what is going through his mind and we simultaneously obtain a variety of physiological measures, we can determine whether a specific physiological indicator correlates with the subject's verbal report . . . . Through the combined use of verbal reports and physiological measures, "subjective" states of consciousness can be studied with a scientific precision that was, until recently, unavailable. (p. 30)

It is conceivable therefore, that with the advent of the "science of subjective experience," psychological and educational measurement may achieve within the foreseeable future the status of a science rather than a prescience.

Hemisphericity

With regard to the psychophysiological approach to cognitive functioning, one of the major investigative techniques involves correlating brain hemispheric function or dysfunction with cognitive processing.

History of Hemisphericity

Interest in the functioning of the left and right hemispheres and its implications for human cognition can be traced back to ancient Greek times. For, it has been found that "according to Hippocrates the human brain is double." (Chadwick & Mann, 1950, p. 83). Plato also, according to an account by Cicero (Rather, 1965), divided the mind into separate entities, "one partaking of reason and the other devoid of it." (p.4).

The first documented account relating to the idea of hemispheric specialization of function was attributed to Goethe (1796) in his description of the association between lesions in the left hemisphere and the inability to speak (Goodglass & Quadfasel, 1954). However, Marc Dax is credited with presenting the first formal theory of localization of speech in the left hemisphere in 1811 (Goodglass & Quadfasel, 1954), followed by Broca in 1865 (Eccles, 1973), who also posited a theory of specialization of the left hemisphere for speech. In 1866 Jackson performed the

first medical investigation to determine the relationship between brain lesions and aphasia (disturbance of language due to a brain lesion but not a result of faulty innervation of the speech muscles, involvement of the organs of articulation, or general mental or intellectual deficiency) (Hinsie & Campbell, 1960). Direct empirical data concerning hemispheric correlates to cognitive functioning has been collected for over a century.

Methods of Investigation of Hemispheric Functioning

In an effort to conclusively establish correlational relationships between cognitive functioning and hemispheric processing, several methods of investigation have been employed. A review of representative studies (See Table 1) conducted primarily within the last 10 years, suggests that the investigative techniques employed can be classified in three major categories: medical intrusive, medical non-intrusive, and non-medical non-intrusive. A brief description of the techniques utilized follows.

Medical intrusive techniques. Essentially, medical intrusive methods of study involve direct surgical inspection or alteration of the brain structure or function. Methods within this category include, but are not limited to, commissurotomy, electroconvulsive therapy (ECT), hemispherectomy, lobectomy, and lobotomy. Commissurotomy or "split brain research" (Gazzaniga, 1967) involves the severing of the connection between the two halves of the brain or the corpus callosum. This technique is used to eliminate epileptic seizures (Ornstein, 1972; Sperry, 1964).

Hemispherectomy denotes the surgical removal of a hemisphere (Burkland & Smith, 1977). Lobectomy involves the removal of neural tissue from a frontal lobe (lobes) (Maksymczuk, 1973). Electroconvulsive therapy (ECT) involves the temporary application of measured electrical current to the temple area(s) via electrodes, in order to induce temporary loss of orientation (Hinsie & Campbell, 1960). Lobectomies, lobotomies, and ECT are procedures that were initially implemented to provide relief for patients under severe psychological distress. These techniques have become much less prevalent in the United States as a result of undesirable side effects experienced by patients (Hinsie & Campbell, 1960).

Medical non-intrusive techniques. The medical non-intrusive techniques include the analysis of electroencephalograms (EEG) and diagnosis of lesions. Electroencephalography is the process of making a graphic recording of electrical phenomena associated with brain activity by means of electrodes attached to the scalp (Hinsie & Campbell, 1960). Diagnosis of unilateral lesions is determined by making inferences concerning the status of the physical structure of the brain based on observable behaviors such as speech disorders (Luria, 1969).

Non-medical-non-intrusive techniques. Included in this category are dichotic listening tasks (Kimura, 1967), visual field tasks (Day, 1964), saccadic (eye) movement analysis (Harnad, 1972), and laterality (handedness) observation (Williams, 1975).

Dichotic listening tasks refer to the application of different stimuli (e.g., two different verbal messages) to both ears simultaneously to determine which hemisphere more effectively processes verbal messages (Harriman, 1947). In visual field experiments the subject's visual field is separated into right and left visual fields by providing a partition at the visual midline (Olson, 1977). Saccadic tasks involve the observation of predominant eye movement patterns during certain tasks (Harnad, 1972). The basic underlying assumption of all these techniques is that there exists contralaterality of hemispheric processing. That is, when stimuli are received in the right visual, auditory, or sensory field, it is assumed that these stimuli will be processed in the left (opposite) hemisphere (Lawson, 1975; Kimura, 1967; Williams, 1975). For example, according to the principle of contralaterality of hemispheric processing, if the prevalent eye movement during a task was to the left, then, hypothetically, the right hemisphere would be the predominant hemisphere involved in processing the information in the task.

Approximately 52% of the studies reviewed utilized medical-intrusive investigative techniques (diagnosed lesions, ECT, commissurotomies, lobectomies, hemispherectomies) to ascertain the functional organization of the cerebral hemispheres, whereas the major medical non-intrusive method to determine hemispheric processing was the electroencephalographic record (EEG)

which was employed in about 23% of the studies. Collectively, the non-medical non-intrusive investigative procedures (dichotic listening tasks, saccadic eye movement observations, visual field tasks and handedness observations) were used to make inferences about hemispheric processing in the remaining 25% of the studies reviewed. Of the non-intrusive methods of investigation, EEG's and visual field studies were more prevalent. The method of assessing hemispheric involvement which is currently receiving the most attention is EEG analysis (Brown, 1977; Green, 1970; Ornstein, 1978). Further discussion of the use of the EEG in researching hemispheric functional organization will be pursued in subsequent sections of the review.

In combination, the studies reviewed involved nearly 1,600 subjects. Interestingly, the study results derived from methods of investigation which might be considered less "direct" (non-medical non-intrusive) generally concur with the findings derived from more rigorous and empirical (medical-intrusive) experimental techniques (See Table 1).

The modus operandi utilized in the majority of these studies to ascertain the nature of hemispheric involvement in the processing of task stimuli (verbal, nonverbal, etc.) was primarily the observation of the association between the lack of the ability to process in a particular way and the diagnosed anatomical aberrations of a particular hemisphere. For example, in one experiment (Vega & Parsons, 1969) two groups of subjects, one group the control group, the other group known

to have lesions in the left hemisphere, were compared on task performance on a criterion measure (Wechsler Adult Intelligence Scale). It was found that there was a significant difference in performance on the criterion variable (verbal scores were lower for the brain lesion group) and this difference was explained best by the diagnosed brain integrity status (no left hemisphere lesions versus left hemisphere lesions present) of the subject. It was therefore inductively reasoned that the left hemisphere was involved in processing language.

The alternative investigative approach was to utilize indicators of hemispheric involvement (EEG, saccadic eye movement, etc.) in neurologically intact (no brain dysfunction or anatomical abnormalities) subjects to determine which hemisphere was predominantly involved in the processing of the task stimuli. As an example of this method of investigation, Ornstein (1978) recorded the EEG patterns of a subject during two tasks, reading a technical manual and reading interesting prose. There was a significant difference in the EEG patterns as a result of performance of the different tasks. Consequently, Ornstein concluded that technical reading was processed primarily in the left hemisphere, since the EEG pattern indicated involvement of that hemisphere during the technical reading task. Reading of interesting prose involved both right and left hemispheric processing, since both the left and right hemispheres were determined to be actively involved from the EEG pattern.

A newly designed paper and pencil self re[illegible]forced choice questionnaire, developed by E.P. Torrance et al. (1978) appears to be a useful tool for future research in hemisphericity. This device, entitled Your Style of Learning and Thinking was developed on an a posteriori basis after an extensive review of the literature on hemispheric functioning as it relates to education. Although at an incipient stage, this device appears to have adequate "face" validity. That is, the questions posed in the questionnaire seem to correspond to theorized associations between preferred cognitive styles and predominant hemispheric processing modes. The standardization sample for this device consisted of approximately 1,000 subjects, and data analyses are now being conducted to determine the validity and reliability statistics. This instrument was designed to be administered to high school and college students in order to provide information to the student and teacher on what learning-teaching styles may be most appropriate for the student.

A review of the representative theoretical literature relating to hemisphericity published primarily within the last 10 years was also conducted. These articles were organized according to major areas of functioning discussed in the article. The articles were also arranged in reverse chronological order to provide an overview of the trends in the literature on hemispheric functioning (See Table 2).

There was general agreement between the results of the empirical studies and the conclusions drawn in the literature reviews concerning non-empirical studies of the functional organization of the cerebral hemispheres. Therefore, both sources were interchangeably utilized to deductively arrive at the

generalizations concerning the relationship between cognitive and affective functioning and hemispheric involvement in these processes that are presented in this paper. The major theories and findings regarding the hemispheric processing modes (left, right or integrative) will be presented as they relate to structural and functional dominance, verbal and nonverbal functioning, educational concomitants, cognitive styles, and the affective states associated with left or right hemispheric functioning.

Left Hemispheric Processing

Dominance

The left hemisphere has historically been considered the dominant or major hemisphere because it was hypothesized that this hemisphere was primarily responsible for the processing of language and planning: the two functions which clearly distinguished man from the rest of the animal kingdom (Bronowski, 1973). Interestingly, it has been found that the left hemisphere is, in fact, anatomically larger than the right hemisphere, as evidenced by neonatal studies (Geschwind, 1972). Furthermore, it has been found (Darvaj & Smýk, 1972) that the left hemisphere is predominantly more active than the right hemisphere in most adults, as indicated by EEG analyses.

The Left Hemisphere and Verbal Processing

The empirical evidence in support of the left hemisphere's involvement in language processing is substantial (Basser, 1962; Brown, 1977; Cherlow & Seraftinidis, 1976; Paglioni, Spinnler & Vignolo, 1969; Fromholt, Christensen

& Strongren, 1973; Gruzelier & Hammond, 1976; Kimura, 1967; Ornstein, 1978) but not unequivocal. More specifically, Goodglass and Quadfasel (1977) found that out of 123 left-handed subjects, only 53% were left hemisphere dominant for language processing, whereas for the other 47% the right hemisphere was predominantly utilized for language processing.

Another noteworthy aspect of language and hemispheric processing is the apparent plasticity or interchangeability between hemispheres for processing before five years of age (Calearo, 1975; Harris, 1975; Pinous, 1974). This theory regarding the interchangeability of function between hemispheres before the age of five is supported by the observation that if a child experiences brain damage to the left hemisphere before five years of age, language function is often successfully shifted to the right hemisphere; whereas, after the age of five, the older the individual is when damage to the left hemisphere occurs, the greater the degree and duration of the loss of language function (Pinous, 1974). A third variable which appears to influence which hemisphere will dominate in the processing of stimuli in general, is the sex of the individual (Harris, 1975; Kimura, 1973). It has been discovered that females, in comparison to males, demonstrate a greater tendency to verbally encode any task (Harris, 1975; Kimura, 1973). That is, if the task involves spatial reasoning (e.g., determining common elements in a series of designs), although this task would be considered to be primarily nonverbal and consequently right hemisphere (Newton, 1975; Schwartz, Davidson & Pugash, 1976), in females there would be a

greater than chance probability that the left hemisphere would be involved in the processing of this task, as determined by EEG patterns (Schwartz, Davidson, & Pugash, 1976). In light of the apparent influence that the subject variables handedness, age, and gender appear to have in determining what the preferred processing style and concomitant hemispheric involvement may be, studies on hemisphericity should be reviewed with attention to these variables.

The studies reviewed in this paper were selected on the basis of the adequacy of sample description in order to control to some degree for the confounding variables of age and handedness. Most studies reviewed utilized right-handed subjects with a chronological age of at least ten years (most subjects were adults).

The reception of spoken language. A most ingenious non-intrusive technique employed to determine the hemispheric correlates of the retention and comprehension of spoken language is the dichotic listening test utilized by Kimura (1961). Basically, a subject is fitted with an independently driven earphone over each ear and is delivered two different messages simultaneously, a different message to each ear. It was found that verbal messages provided to the right ear were retained to a significantly greater degree than the message given to the left ear, although there was a definite left ear advantage for the recall of musical stimuli. Kimura reasoned that according to the principle of contralaterality (the hemisphere opposite the side of sensory input is dominant in processing), the left hemisphere was dominant in the

comprehension and retention of language, and the right hemisphere was more adept at the processing and recall of musical patterns. Kimura's dichotic listening experiment findings have been successfully replicated (Springer, 1971; Shankweiler, 1966). Other researchers (Cherlow & Serafetinides, 1976; deElia, Lorentzson, Maotma & Wilepalm, 1976; Fromholt, Christensen & Stromgren, 1975) have also concluded that short term memory, that is, the type of recall which enables conversational speech to occur through retention of what is being said in the immediate conversation, is primarily in the dominion of the left hemisphere.

The expression of language. With respect to the expression of language through speech, several investigators have concluded that it is exclusively processed in the left hemisphere (Burkland & Smith, 1977; Eccles, 1973; Nebes, 1974; Sperry, 1974; Zellinger, 1935). No salient evidence to contra-indicate this contention was found in the review of the literature.

Communication through writing and hemispheric involvement are not as clearly defined as communication through speech and hemispheric processing. Although the verbal aspect of writing is predominantly a function of the left hemisphere, the visual motor aspect of writing appears to be within the realm of the right hemisphere (Benton, 1969; Brandwein & Ornstein, 1977; Vega & Parsons, 1969). Thus, a transference from left hemispheric processing to right hemispheric processing appears to be involved in writing.

The Left Hemisphere in Education

The role of the left hemisphere in education with respect to the traditional Basic Skills or "3R's" is well documented. Reading is considered to be principally a left hemisphere function (Hunter, 1976; Newton, 1970; Sperry, 1974). Mathematical functions, particularly calculation (Callaway, 1974; Day, 1964; Dumas, 1975; Olson, 1977) and algebra (Hunter, 1976), are postulated to be left hemisphere operations. Writing, as previously mentioned, appears to require cooperation from both hemispheres (Smith, 1972).

Cognitive Styles and the Left Hemisphere

An area of functioning which is now attracting much attention is problem-solving strategies and how they relate to hemispheric processing. Research in this area suggests that the type of thinking strategy most characteristic of the left hemisphere is analytical (Brandwein & Ornstein, 1977; Maksymczuk, 1973; Salk, 1973), sequential (Gruzelier & Hammond, 1976; Luria, 1970), and logical (Kraft, 1976; Lawson, 1975; Papoun, 1974). Studies indicate that when fine discriminations or differentiations of stimuli are required, the left hemisphere is predominantly involved (Epinas, 1975; Semmes, Weinstein, Ghent & Teuber, 1960; Wood, Goff & May, 1971). The acquisition of new habit patterns is also considered a left hemisphere function (May, 1977). Morie and Piercy (1952) have proposed that the left hemisphere is well suited for the "education of relations" which is essentially the ability to analyze the common aspects of a task and formulate systematic

relationships among these tasks.

Affective Concomitants of the Left Hemisphere

It has also been postulated that certain affective states coincide with left hemisphere functioning. It is contended by Dimond et al. (1976) that positive emotions are associated with the left hemisphere, and that these positive emotions are present when the left hemisphere is processing stimuli that are orderly and consistent. Emotional irritation is an hypothesized concomitant of the left hemisphere's processing of information that is characterized by contradictions and inconsistencies (Hadamard, 1945; Hebb, 1966).

Right Hemispheric Processing

Non-Dominance

The right hemisphere, sometimes referred to as the minor or non-dominant hemisphere was found by Geschwind (1970) to be anatomically smaller than the dominant or left hemisphere. In an EEG study conducted by Darvai and Smyk (1972) it was discovered that for adults the right hemisphere is actively processing information less often than the left hemisphere.

The Right Hemisphere and Verbal Processing

As more research on hemisphericity is being conducted, it is becoming evident that the right hemisphere is not totally silent. In fact, as mentioned before, the language function is somewhat more equally shared between hemispheres before the age of five (Lenneberg, 1967),

and for left-handed adults (Goodglass & Quadfasel, 1954). Furthermore, the results of studies demonstrate that the right hemisphere is capable of processing language if the discriminations are uncomplicated (e.g., a positive from a negative statement) (Butler, 1968) if sufficient time is allowed (Bogen & Gazzaniga, 1965; Gazzaniga & Hillyard, 1975; Nebes & Sperry, 1971; Weisenberg & McBride, 1935). It was found by Moscovitch, Scullion, and Christie in 1976, that sufficient time for right hemispheric processing of "uncomplicated" discriminations was 100 msec, or double the amount required for the left hemisphere to process the same information.

The analysis of voice intonation, an integral component of language, appears to be a function of the right hemisphere (Van Lanker, 1975). The primary expressive mode of the right hemisphere is speculated to be metaphorical in nature (poetry, analogies) (Eccles, 1973; Ornstein, 1972; Samples, 1975); however, in general the verbally communicative ability of the right hemisphere is relatively limited and dependent upon the left hemisphere.

The Right Hemisphere and Nonverbal Processing

Visual processing. The interpretation of complex visual patterns has been found by several researchers to be a predominantly right hemisphere function (Compton & Bradshaw, 1976; Goyvaerts, 1975; Moscovitch, Scullion & Christie, 1977; Schwarts, Davidson & Pugash, 1976). Further, the right hemisphere is much more adroit in the recognition of faces (Hecaen, 1975; Hillard, 1973; Muller, 1973), while the left hemisphere

remembers the names that go with the faces. The retention of visual patterns, such as geometric designs and graphs is believed to also be in the dominion of the right hemisphere (Hines, Sutker, Satz & Altman, 1976; Smith, 1967; Vega & Parsons, 1969). It is also contended that the iconic presentation of information (e.g., graphic displays, diagrams, flow charts, etc.) greatly facilitates both the comprehension and retention of information, and that iconic memory is primarily a function of the right hemisphere (Taylor, 1978). Visuo-spatial perception and reasoning, which are posited to be right hemispheric operations (Benton, 1969; Hunter, 1976; Kinsbourne & Smith, 1974; Knox & Kimura, 1970; Milner, 1971; Warrington & Rabin, 1970), are the processing skills that are required in such tasks as architecture and sculpture.

Auditory processing. For most individuals, the perception and retention of complex nonverbal auditory patterns, such as music or morse code occurs in the right hemisphere (Buffery, 1976; Dumas, 1975; Entus, 1975; Paglioni, Springer & Vignolo, 1969; Kimura, 1973; Molfese, 1975; Olson, 1977; Schwartz, Davidson & Pugash, 1976). It should be noted, however, that Bever and Chiarello (1974) reported that experienced musicians analyze musical patterns via the left hemispheric processing mode, similar to the manner in which most individuals analyze speech patterns.

Proprioceptive processing. Awareness of body position, spatial orientation, and the perception of fine and gross motor activities all come within the realm of the right hemisphere (Brandwein & Ornstein, 1977;

deRenzi & Nichelli, 1975). This kind of bodily awareness is the sine qua non of ballet and other types of dance, gymnastics, and most activities requiring synchronized bodily movements. Haptic or tactile perception is contended by Kimura (1973) to be a right hemispheric function, based on the observation that there is a pronounced preference for the left hand to be used in the reading of braille. This inference is based upon the principle of contralaterality of hemispheric processing.

The Right Hemisphere in Education

The subjects that are speculated to be processed by the right hemisphere are art, music, and physical education (Samples, 1975). Geometry, which is primarily iconic (graphic) in its format is also attributed to right hemispheric processing (Hunter, 1976).

Cognitive Styles and the Right Hemisphere

The cognitive styles which are considered characteristic of right hemispheric processing are those skills which are indispensable for generating solutions to problems for which there are no apparent answers. The functions of the right hemisphere have been described as creative (Bogen, 1969; Harnad, 1972; Tart, 1972; Torrance, 1978) and divergent (Kinsbourne & Smith, 1974 ; Peronne & Pulvino, 1977; Samples, 1975; and Williams, 1976). Another characteristic of the right hemisphere is the capacity to simultaneously (but not sequentially) process several variables, or to deal with information analogically (Salk, 1976).

The ability to obtain a global view or a "gestalt" of a situation or task also appears to be a primarily right hemisphere capacity (Dimond & Beaumont, 1974; Papcun, 1974).

The right hemisphere, perhaps because of its capacity to process multiple stimuli simultaneously, has been described as being satisfied with "approximate knowledge" (Prince, 1976), and is more diffuse and less clearly demarcated in its cognitive style than the left hemisphere (Semmes, Weinstein, Ghent & Teuber, 1960). The "Education of Correlates" (May, 1977) or the ability to analogically perceive relationships among apparently unrelated concepts or stimuli (which could be considered to be tantamount to deductive or generalization ability) also relies predominantly upon the right hemisphere processing mode. When aesthetic judgment is required in a task, the right hemispheric processing mode is hypothesized to be prevalent, according to the findings of Hadamard (1945) and Hebb (1966).

Affective Concomitants of the Right Hemisphere

It is contended (Schwartz, 1975) that the right hemisphere plays a predominant role in the affective domain. Research indicates that the right hemisphere is generally involved in aesthetic judgment tasks, and when the stimuli being processed are perceived as aesthetically harmonious, the accompanying affective state is pleasurable and positive. Negative emotions are believed to be associated with the right hemisphere's processing of stimuli which are perceived as discordant or cacophonous.

In summary, this overview of the literature on hemisphericity suggests the following divisions of functioning between the left and right hemispheres. The expression (written and oral) and reception (reading and aural) of language for right-handed adolescents and adults is primarily a left hemisphere function, although metaphorical and analogic verbal reasoning seem to have definite right hemisphere components. The right hemisphere appears to be more responsible for interpretation and retention of nonverbal visual (iconic) and auditory (musical) patterns. The left hemisphere's role in education is primarily in the more traditional Basic Skills (reading, writing and arithmetic); whereas art, music, dance and physical education appear to be more in the realm of the right hemisphere. With respect to cognitive styles, the problem-solving strategies of the left hemisphere have been described as discrete, logical, inductive, sequential and convergent, whereby the right hemisphere problem-solving strategies are characterized as diffuse, deductive, simultaneous, and divergent. Affective responses, especially with respect to aesthetic judgment are generally considered to be predominantly right hemisphere concomitants. Emotions associated with the left hemisphere are believed to be responsive to congruencies or consistencies in logic.

Communication Between the Hemispheres

Israel Scheffler, in his 1976 address to the American Psychiatric Association coined the term "cognitive emotion" to denote the necessity of bridging the gap between "unfeeling knowledge" (left hemisphere

development only) and "mindless arousel" (right hemisphere development only). In essence, Scheffler emphasized the need for a more integrated approach to education; that is, to actively encourage the use of emotions (through discovery learning, etc.), which would facilitate and enhance learning experiences. This integrated approach to education can be facilitated by involving the total individual in the learning process rather than relying exclusively on the student's cognitive skills.

Scheffler's notion concerning the need to integrate both the cognitive (left hemisphere) and emotional (right hemisphere) aspects of the student's learning capacity in order to maximize the learning experience is supported by empirical research. A study conducted by Kraft (1976), involving the measurement of EEG patterns of 6-to 8-year-olds while engaged in selected "Piagetian" tasks, showed that those children who were using both hemispheres (as indicated by the EEG reading) throughout all tasks performed better on both nonverbal (right hemisphere tasks) and verbal (left hemisphere tasks). That is, when the right hemisphere (which is relatively nonverbal) was employed in processing the verbal task in concert with the left hemisphere, performance on this task was better than for those who used only their left hemisphere on verbal tasks. It has been established that communication between the hemispheres occurs through the corpus collasum (a broad white fiber tract which serves as a neural bridge between the hemispheres) (Hinsie & Campbell, 1960).

This neural bridge, however, does not fully mediate communication between the hemispheres until seven or eight years of age (Yakovlev, 1967). Due to the fact that there is less communication between the hemispheres before seven or eight years of age (and experiences are consequently not as readily shared between hemispheres), the overemphasis on development of one hemisphere to the neglect of the other hemisphere can preclude normal affective or cognitive development. A study by Crinella, Beck and Robinson (1971) strongly suggests that failure to stimulate both hemispheres during early childhood may be a causal factor in behavioral and emotional difficulties. These authors assert that an unbalanced emphasis on the precocious attainment of a talent early in the child's life may have permanent effects on his/her emotional development.

With respect to cognitive development and balanced stimulation of the hemispheres, as the result of analyses of the 1960's preschool compensatory educational programs, Passow (1964) concluded that children from homes that lacked visual-sensory stimulation (a right hemisphere function) had lower intellectual capabilities than other children. Passow considered this trend irreversible if adequate visual stimulation was not provided before the age of six. Furthermore, stimulation of right hemisphere processing can increase measured intelligence. Rennels (1976) found that 60% of the abilities IQ tests are reported to measure were found to involve right hemisphere processes.

To further illustrate the necessity for cooperation between hemispheres, it has been postulated that females are generally somewhat more adept at switching from one hemisphere to the other, as evidenced by EEG studies (McGuiness & Pribram, 1978). It is also speculated that on handwriting tasks males usually experience a greater degree of difficulty than females because of the necessity to shift between hemispheres (McGuinness & Pribram, 1978). That is to say that transfer from the verbal mode (left hemisphere) to the visual motor (right hemisphere) is slightly more difficult in males than in females.

Short term memory, which is primarily within the realm of the left hemisphere (deRenzi & Nichelli, 1975) is significantly impaired when the corpus collasum is severed, as evidenced by a study conducted by Zaidel and Sperry (1973). This indicates the importance of interhemispheric communication even for left hemispheric processing.

A study involving 350 college students conducted by Noller and Parnes (1972) to determine the effectiveness of creativity training on improving divergent performance on the "Structure of Intellect" tests found that the divergent production scores on the S.O.I. did in fact significantly increase as the result of the creativity training. It was also discovered that convergent performance on the S.O.I. (a left hemisphere function) also improved significantly. This again suggests the interdependency between the hemispheres for optimal cognitive functioning.

Samples (1975) has proposed a model for cognitive functioning entitled "the inventive mode" which in essence, is the overlapping of the functions of the two hemispheres. The result of this overlapping of functions is a type of operation which is qualitatively different from either hemisphere functioning independently. Samples described this inventive mode as "when the mind uses existing knowledge to create objects and processes that have never existed before" (1975, p. 20). It is also suggested by several researchers that the highest levels of creative or divergent functioning encompass the highest levels of convergent and metaphoric thinking (Debono, 1972; Getzels & Jackson, 1962; Johnson, 1972).

Jonas Salk in his book Survival of the Wisest (1973), stressed the importance of the synthesis of the intuitive-metaphoric (right hemisphere) and the rational-logical (left hemisphere) processing modes in major scientific breakthroughs.

According to Crinella, Beck and Robinson (1971), man's highest and most creative achievements require a "complementary different" relationship between the hemispheres. That is to say that although both hemispheres are different in functional styles, through a synergetic or complementary synthesis of the capacities of both hemispheres, man can be the most creatively productive.

Sperry (1973) has reported that when functioning in this "synergetic" or creative mode, physiological integration of the hemispheres is evidenced

by means of the EEG record, and that this hemispheric synchrony is accompanied by the subjective experience of physiological harmony. The results of several studies strongly suggest that there are indeed physiological correlates to these states of creative or synergetic modes of functioning (Brown, 1977; Budzynski, 1971; Green, 1970; Jacobson, 1975; Kamiya, 1969; Luria, 1970; Paskewitz, Orne & Castello, 1970). Norman (1977) analyzed over 8,000 EEG records and concluded that "insights on problems represented a higher level of organization of the brain " (p. 15). Norman indicated that the subjective reports that accompanied these higher levels of brain organization patterns were similar to Maslow's description of "peak experiences".

Maslow (1962) has in fact, concluded that there was a similarity between "peak" or "self actualization" experiences and the affective aspect of the creative act. Many accounts of this peak or actualization experience during the creative act have been reported by noted scientists (Ghiselin, 1952; Gilchrist, 1970). Garret (1976) has asserted that this feeling of integration or harmony is associated with hemispheric integration. That is, the original vision of the right hemisphere is communicated through the verbal facilities of the left hemisphere. This integrative state between hemispheric processes, however, is not considered typical of mental functioning (Kamiya, 1969). According to the theory of "reciprocal inactivity" of the hemispheres postulated by Gazzaniga and Hillyard (1971), several EEG study findings indicated that when the left hemisphere is processing information,

the right hemisphere tends to become relatively inactive. Conversely, the left hemisphere exhibits relatively less activity when right hemispheric processing is called upon. Research conducted by Levy (1969) suggests that the occurrence of integrative hemispheric functioning can be significantly increased by the method of presentation of materials to be learned. For example, exercises such as "define the words (a verbal left hemisphere function) anger and hate" (an affective, primarily right hemisphere operation) facilitate processing from both hemispheres. As previously mentioned, Ornstein (1978) has suggested that the reading of what is judged by an individual to be interesting prose encourages the use of both hemispheres in processing. Singing is another example of an activity that involves synchronized processing of the two hemispheres (the lyrics are processed in the verbal left hemisphere and the musical component is processed in the right hemisphere).

In conclusion, the necessity for attention to the stimulation of both the left and right hemispheres appears to be essential for the normal cognitive and affective development (Crinella, Beck & Robinson, 1971; Passow, 1964; Rennels, 1976) of the individual. Furthermore, it has been indicated that this balanced approach to brain functioning should be initiated early in an individual's development (Crinella, Beck & Robinson, 1971; Passow, 1964; Yakovlev, 1967).

A symbiotic relationship between the functioning of the hemispheres is suggested by the findings that indicate that training for right hemispheric processing often benefits left hemispheric processing (Noller & Parnes, 1972; Samples, 1975).

The communication between the hemispheres, described as "the inventive mode" by Samples (1975), and associated with highly creative production and problem solving (Ghiselin, 1952; Gilchrist, 1970; Kraft, 1976; Norman, 1977), appears to have subjective (Maslow, 1962) and physiological correlates (Brown, 1977; Budzynski, 1971; Green, 1970; Jacobson, 1973; Kamiya, 1969; Luria, 1970; Paskewitz, Orne & Castello, 1970; Sperry, 1973). Although this integrative state is not typical of hemispheric functioning (Gazzaniga & Hillyard, 1971), the synchronous use of both hemispheric processes can be facilitated by the management of the student's learning experiences (Levy, 1969; Ornstein, 1978; Samples, 1975) (e.g., providing exercises which will call upon processes that are associated with both hemispheres). Another approach to encouraging the occurrence of this "inventive mode" or integrated state of hemispheric processing is based on the psychophysiological approach to cognitive functioning, or the "science of subjective experience."

The Physiological Correlates of Cognitive and Affective Functioning

The major premise behind the "science of subjective experience" as proposed by Davidson and Krippner (1971), is the ability to accurately establish associations between reported subjective experiences (cognitive and affective) and physiological measures. The most accurate non-intrusive physiological index used to ascertain brain activity as it is related to subjective experience is the graphic recording of the measurement of the electrical potential associated with this brain activity. This graphic recording is called an electroencephalogram (EEG).

In 1924, Berger conducted the first EEG, and has thus been credited with the establishment of the use of the EEG as an indicator of brain activity (Brazier, 1968). The EEG has been accepted as an integral tool in the physiological examination of the brain (Hinsie & Campbell, 1960).

EEG Correlates of Subjective Experiences

Barbara Brown (1977), as a result of her extensive review of the literature on EEG studies as related to cognitive and affective states, has concluded that the EEG can be considered an approximate "mirror" of the bioelectrical activity patterns which occur during reported cognitive and affective states. The cognitive and affective functioning paradigms derived from EEG pattern analysis appear to be accurately predictive (Brown, 1977; Green, 1970; Kamiya, 1968; Luria, 1970; Ornstein, 1978). In fact, based on the results of a study conducted by Darwai and Smyk (1972), it was concluded that EEG pattern analysis is the most accurate measure of the neurological concomitants of mental activity because it is the total resultant of bioelectrical activity of the neurons (brain cells). This ability to more directly observe mental processes through the signature of the EEG pattern is providing an unprecedented degree of empiricism to the study of cognitive and affective functioning. This greater degree of empiricism through the use of EEG pattern analysis as compared to paper and pencil tests or observation of overt behaviors, is due to the contention that EEG pattern analyses are more direct and reliable measures of determining the actual neurological processes of the

brain, and that these frequencies can be classified into four basic EEG wave pattern categories: delta, theta, alpha and beta.

Delta. The delta EEG wave pattern is characterized by slow frequency waves ranging from .5 to 3.0 cycles per second (Hz.) (Brown, 1977; Green, 1970). The delta EEG pattern is recorded most often during the deeper stages of sleep, and is associated with the dream state (Brown, 1977; Green, 1970).

Theta. The theta EEG wave pattern has a relatively faster frequency than the delta EEG pattern, generally occurring within the 3.5 to 7.5 Hz. (cycles per second) frequency range. Theta is most often recorded during the preconscious (semi-sleep state); that is, between dreaming and waking. It has been found that most individuals are in this theta state about 5% of the time (Green, 1970). Evidence indicates that it is during this state between dreaming and waking, which is consistently characterized by the theta wave pattern, that insights or shifts in perspective (Budzynski, Stoyva & Adler, 1970; Brown, 1977; Gowan, 1975; Green, 1970; McKellar & Simpson, 1954; Norman, 1977; Sittenfeld, 1972) and states of reverie occur (Green, 1970). These "insight-reverie" states are considered to be essential components of creativity (Davidson & Krippner, 1971; Foulkes, 1965; Luthe & Geissmann, 1963). Several studies of creative genius indicate that highly creative individuals experienced their most creative insights during states of dreamlike "reverie" whereby reality testing was temporarily suspended (Ghiselin, 1952; Gowan, 1972; Green, 1970). One of the most celebrated

examples of creative insight being expressed during this dreamlike state was that of Kekule',who is credited with the discovery that some organic compounds occur in closed chains or rings. It is reported that while Kekule' was in a semi-sleep state, a mental image of a snake biting its tail appeared, which Kekule' utilized as the basis for the structural theory of the benzene ring (McKellar & Simpson, 1954). Green (1970) has stated that "there are hundreds of anecdotes which show beyond doubt, that in some way,[although] not perfectly understood, reverie and creativity are associated"(p. 18). As previously indicated, it is estimated that only 5% of our time is spent in this "reverie state", as measured by the EEG record. Walkup (1965) has suggested that those individuals who have been considered truly creative, are those individuals, who perhaps through serendipity, have learned how to consciously bring about these reverie or insight states. In an address to the American Psychological Association in 1964, MacKinnon also proposed the theory that truly creative individuals possess the unique ability to consciously elicit these "reverie or insight" states.

Alpha. The alpha wave pattern is typified by EEG frequencies in the 8 to 13 Hz. range (Brown, 1977; Green, 1970; Hinsie & Campbell, 1960). The cognitive styles which are associated with this alpha state have been described as receptive (Brown, 1977), problem finding (Deikman, 1971; Murphy, 1958), field independent—attention is internally focused (Kasamatsu, 1963), and narrowing of the perceptual field (Honorton, Davidson & Bindler, 1972; Lynch & Paskewitz, 1971). Illumination, insight or reverie experiences

are also reported to occur during this state (Budzynski, 1971; Gowan, 1972; Green, 1969, 1970; Kamiya, 1969; McKellar & Simpson, 1954; Norman, 1977). A state of "relaxed wakefulness" (Brown, 1977; Lindsley, 1960; Nowlis & Kamiya, 1970) is usually expressed by individuals who are in this state, as are feelings of integration or unity (Hellas & Gaier, 1970; Paskewitz, Lynch, Orne & Castello, 1970; Schwartz, 1976). This state may further be described as that in which one is involved in a routine and not difficult cognitive task. It is reported that when Einstein was solving complex mathematical equations, his EEG pattern indicated that he was in the alpha range. However, when he was presented with a problem to solve which he had never encountered before, his EEG pattern reflected a higher frequency (beta range) (Brown, 1977).

Beta. The beta EEG pattern, which ranges from approximately 15.5 to 4.0 Hz. in frequency is generally accompanied by reports of externally focused attention (field dependency) (Deikman, 1971; Salamon & Post, 1965), and this increased external focus is evidenced by findings that reaction time to external stimuli is fastest in the beta state (Woodruff, 1975). This beta state has also been interpreted as being typified by increased problem solving ability (Sheer, 1975). Deikman (1971) has stated that psychological manifestations of the beta state are "object based logic, heightened boundary perception, and dominance of formal characteristics over the sensory; (i.e., shapes and meanings have a preference over colors and textures)" (p. 59). These characteristics of the beta state are considered

by Deikman (1971) to be suggestive of what Deikman has coined the "action mode", which is evidenced by externally focused attention and goal orientation. Sheer (1970, 1972, 1975) has conducted studies which confirm Deikman's theory about the relationship between the beta state and the "action mode." Sheer (1970, 1972) discovered that the 40 Hz. range (the upper end of the beta frequency range) was optimal for short term memory, serial learning tasks, and math calculations. Although Sheer's findings are considered tentative, other researchers support the contention that an association between the beta state and increased problem solving ability does exist (Brown, 1977, Gowan, 1975).

According to Brown (1977), the affective states which appear to coincide with the beta EEG pattern or "action mode" (Deikman, 1971) are generally reported to be varying degrees of anxiety and apprehension.

Hemispheric Processing and EEG Patterns

Through examination of the literature reviewed on hemispheric processing and EEG pattern analysis, associations between hemispheric processing and EEG patterns appear to emerge. These associations are presented in Table 5. An analysis of the literature suggests that as the frequency range of the EEG pattern (from .5 to 40 Hz.) increases, cognitive and affective states acquire characteristics which are increasingly more reflective of left hemisphere functioning. For example, at the lower frequencies of the EEG spectrum (alpha— 8.0 to 13 Hz.), the cognitive and affective manifestations such as internal focus of attention (Epinas, 1975) and a sensation of

relaxed wakefulness or pleasure (Hebb, 1966) coincide to a great degree with the description of cognitive and affective states, which are considered to be in the realm of the right hemispheric processing mode. As the EEG pattern frequency increases, the cognitive styles and affective experiences appear to represent more left hemisphere operations. The EEG pattern which is at the upper end of the frequency spectrum (the beta frequency range—14 to 40 Hz.) is characterized by cognitive and affective functions which are generally considered to be left hemisphere operations, such as convergent problem solving (Perrone & Pulvino, 1977) and negative affect associated with logical inconsistencies (Hadamard, 1945; Hebb 1966). It appears that the integrative hemispheric mode or what has been described by Samples (1975) as "the inventive mode" or by Scheffler as "the state of cognitive emotion," occurs somewhere between the upper end of the alpha frequency range and the lower end of the beta frequency range, which is represented by an intermediate state between the left and right hemispheric processing modes.

It appears possible that through continued and systematic inquiry into the physiological parameters (as measured by EEG pattern analysis) of various cognitive and affective states defined according to hemispheric information processing models, greater scientific knowledge can be accumulated concerning mental functioning.

The Relationship Between Cognitive-Affective and Physiological States

Through the "science of subjective experience" (Davidson & Krippner, 1971), that is, through correlating reported cognitive processing and

affective states with physiological measures (EEG patterns), theoretical models of mental functioning can be established which are more amenable to empirical investigation than previously conceived hypothetical models of cognition and affect.

Recent findings in psychophysiological research suggest that not only can relationships between mental functioning and physiological states be established (as reflected by EEG patterns), but that these physiological states which are associated with certain types of cognitive-affective states can be consciously elicited (Green, Green & Walters, 1970; Kamiya, 1969; Schwartz, 1976). It has been theorized that direct elicitation of specific EEG patterns is not possible because the actual generation of the brain waves cannot be sensed by the subjects themselves. However, it has been empirically and consistently demonstrated that it is possible to consciously and predictably elicit certain physiological states (as measured by the EEG record) by selectively focusing on functions of the central nervous system (muscle relaxation, breathing) or particular thoughts. (Barber, 1971; Budzynski, Stoyva & Adler, 1970; Cacha, 1976; Dicara, 1970; Foulkes, 1965, 1966; Green, 1970; Hord, 1972; Jacobson, 1975; Honorton, Davidson & Bindler, 1971; Kamiya, 1969; Kimmell, 1967; Luthe & Geissman, 1963; Nowlis & Kamiya, 1970; Miller,, 1969; Mulholland & Runnals, 1962; Paskewitz, Orne & Castello, 1970; Schwartz, Davidson & Pugash, 1976; Sheer, 1972; Sittenfeld, 1972).

Green (1970) aptly summarized the reciprocal relationship between cognitive-affective states and concomitant physiological states in the "psychophysiological principle." The principle states as follows: "Every change in the physiological state is accompanied by an appropriate change in the mental-emotional state and conversely, every change in the mental-emotional, conscious or unconscious, is accompanied by an appropriate change in the physiological state" (Brown, 1977, p. 215). Therefore, according to the "psychophysiological principle", it is suggested that physiology and cognitive-affective functioning are yoked and mutually dependent.

The two predominant methods for facilitating desired physiological states (and thus fostering certain mental-emotional states) are Autogenic Training (Green, 1970), and Progressive Relaxation (Jacobson, 1973). In 1910, Schultz developed a systematic method of relaxation which has been further developed by Green (1970) into what is now called Autogenic Training. Jacobson (1932) established the system called Progressive Relaxation in 1907. Both of these techniques require the subject to selectively attend to specific central nervous system functions (muscle relaxation) or particular thoughts (of warmth, sleepiness, aesthetically pleasing subjects). The techniques were originally utilized for elimination or mitigation of inappropriate anxiety symptoms; however, it has been found that deep relaxation is associated with what has been described in subjects' reports as creative or insight states (Brown, 1977). These

relaxation techniques are in essence, an extension of gross and fine muscle pattern learning (learning a sport or learning to draw, etc.). It has been demonstrated that if adequate feedback is provided relating to the system to be controlled, despite the fact that the system is not normally considered to be within the realm of volitional control, it can indeed be consciously controlled (Hart, 1967).

One method of relaxation training involves the use of EEG patterns as the dependent or criterion variable. That is, the individual is instructed to follow a particular relaxation procedure (usually concentrating on breathing or deep muscle relaxation), and the relaxation exercise is considered successful when a specified EEG pattern is elicited. The relaxation training is continued until it is determined to have had transfer value; otherwise stated, when the subject can elicit the EEG pattern without having access to the feedback information. It has been discovered that when subjects succeeded in producing the alpha EEG pattern, not only were the anxiety symptoms allayed, but the subjects reported shifts in cognitive styles and affective states. These states appeared to be closely related to insight states reported by creatively-productive individuals (Brown, 1977; Green, 1970).

Kamiya (1962, 1967, 1968) is credited with pioneering research related to the conscious elicitation of the alpha EEG pattern as a psychotherapeutic tool to relieve anxiety symptoms. In a paper presented at the 1967 American Psychological Association, Kamiya asserted that not only could alpha EEG

pattern production be taught for the improvement of mental health, but that the ramifications for education in general, would be far-reaching since greater learning and creativity could be facilitated.

In another presentation to the American Psychological Association in 1971, Budzynski stressed the importance of conscious elicitation of both the alpha and theta EEG patterns for the explicit purpose of facilitating the physiological states most associated with creativity.

Thus, the utilization of conscious elicitation of the alpha EEG pattern for the purpose of facilitating the cognitive and affective states associated with creativity appears to be an area of active research (Green, 1960, 1970; Honorton, Davidson & Bindler, 1972; Hord, Lubin & Johnson, 1975; Nowlis & Kamiya, 1970; Schwartz, Davidson & Pugash, 1976, Sittenfeld, 1972).

The Psychophysiological Model of Problem Solving

In 1926, Graham Wallas proposed a 4-stage model of creativity inspired by the eminent German physicist Helmoltz's accounts of the subjective experiences he had encountered while realizing his greatest insights. Wallas' purpose in the development of this model was to emphasize the importance of nurturing greater skill and effectiveness in creative thinking through the self-training of one's natural thought processes (Vernon, 1976). According to Wallas (1926), the creative thinking process consisted of four distinguishable, although overlapping stages. These four stages were:

(1) Preparation: the problem was investigated in all directions.

(2) Incubation: the individual was not consciously thinking about the problem.

(3) Illumination: the appearance of the "happy idea" together with the psychological events which immediately preceded and accompanied the appearance of the happy idea.

(4) Verification: the individual then judges the worth of the solution or product (p. 80).

It is the opinion of this writer that there are both hemispheric and psychophysiological (EEG) correlates to Wallas' four stages of creative thinking which are incorporated in the "psychophysiological model of problem solving." (See Table 4). This psychophysiological model of problem solving is based on findings derived from psychophysiological research. The theoretical bridge between Wallas' creativity model and the findings of psychophysiological research is provided by the theory of "action and receptive modes" proposed by Deikman (1971). Essentially, Deikman has postulated that there are two different modes of awareness. The "action mode" is a state of awareness organized to manipulate the environment and acquire knowledge in order to change the environment. The focus of attention is external and the corresponding physiological indices of the "action mode" are the beta EEG pattern and increased baseline muscle tension. This "action mode" appears to correspond to Wallas' preparation and verification stages in which external focus and reality testing functions are required. In contrast, the receptive

mode is a state which facilitates the intake of the environment rather than the manipulation of the environment. The psychophysiological concomitants of the "receptive mode" are the alpha or theta EEG patterns and decreased muscle tension. It is hypothesized by Deikman (1971) that it is during this receptive state or when the person discontinues to focus consciously on a problem and directs his/her attention to other things, that solutions to problems manifest themselves as an "Aha!", "Eureka!" or "insight experience." This receptive mode could be interpreted as being analogous to Wallas' incubation and illumination stages where attention to the problem is defocused, and solutions or insights to problems spontaneously appear. This receptive mode is usually dominated by the "action mode" in daily functioning, and Deikman suggests that the receptive mode must be learned.

According to the proposed psychophysiological model of problem-solving, it is hypothesized that appropriate shifts in the quality and focus (internal and external) of attention could be consciously elicited through mastery of systematic relaxation techniques. More specifically, control of physiological states associated with particular cognitive styles and affective states could be obtained. Consequently, it would be possible that the most advantageous cognitive or affective mode(s) could be brought about vis-a-vis the problem or stage of problem-solving at hand. In addition, it would be possible to ascertain if this cognitive or affective mode had been achieved by monitoring the physiological indicators (EEG patterns) which have been found to be associated with the desired mode or state. Thus, subjective verbal

reports would not be the sole indication that the desired cognitive or affective mode in the problem-solving sequence had been attained. In essence, according to the psychophysiological model of problem-solving, it would be possible to more operationally define the cognitive and affective modes that would be most appropriate for the type of problem encountered. That is, if through psychophysiological research it was determined that particular physiological states (as indicated by the EEG or other physiological measures) were more conducive to the occurrence of a more creative or receptive mode, individuals could replicate that psychophysiological state and produce the corresponding cognitive or affective mode. For example, as mentioned previously the theta (EEG pattern of 3.5 - 7.5 Hz) state has been associated with the reported "reveries" and insight states (Brown, 1977; Green, 1970). Initially, these findings resulted from research conducted at the Menninger foundation by Green, Green and Walters (1970). The EEG patterns of three scientists (a physics professor, a psychiatrist and a psychologist) who were considered to be creative by their peers, were measured as each consciously produced a mental state which he considered to be associated with creative thoughts. The predominant EEG pattern was the low frequency theta pattern (3.5 - 7.5 Hz). Thus it could be inferred from this study that the "creative state" could be operationally defined as the cognitive-affective experience associated with the production of the theta EEG pattern. In fact, Green, Green and Walters'(1970) findings

which associate the creative state with the production of theta EEG patterns, have been replicated in studies designed to lessen the chances of contamination of results by subject or experimentor biases or expectancies, through the use of double blind and placebo treatment producedures (Paskewitz, Luthe & Castello, 1970). The results of several other studies substantiate the hypothesized relationship between reported "reverie" or creative states and the production of theta EEG patterns (Budzynski, 1971; Davidson & Krippner, 1977; Luthe & Geissman, 1963; Sittenfeld, 1972).

For each stage of the problem-solving process, a range of characteristic physiological measures associated with particular cognitive or affective states could be established and operationally defined. This would perhaps place the study of creativity or problem-solving within the realm of empirical scientific investigation by having quantifiable parameters of the states being studied. A stage in the creativity or problem-solving sequence could then perhaps be defined as that stage (or mode) reflected by a physiological measure (EEG, for example) which corresponds to the most effective cognitive-affective mode for that stage.

Training for Problem Solving

A systematic approach to facilitating problem-solving skills could be designed as follows: First, mastery of an appropriate relaxation technique such as Progressive Relaxation (Jacobson, 1973) or Autogenic Training (Green, Green & Walters, 1970) would be achieved. These relaxation techniques could be incorporated into physical education curricula. Once the

individual demonstrated the ability to consistently elicit particular states of relaxation as indicated by physiological measures, training for transfer to "real life" situations would be undertaken (Wolpe, 1970). An individual profile, combining the hemispheric processing modes and cognitive-affective states which were found to be most advantageous to performance of particular types of tasks with the corresponding physiological state would be established. For example, it may be found that the task of defining a scientific term for a 12-year-old right-handed male might be best processed through the verbal mode (which would most often be a left hemisphere process) in an alert (beta EEG pattern) state; whereas, the task of making a clay object which represented a particular feeling might involve a spatial right hemispheric processing mode in a more relaxed (alpha EEG pattern) state. By means of such a profile a student would not only learn about the nature of his/her intellectual resources, but he/she would also gain more control over these resources, as advocated by Guilford (1975).

With respect to the "psychophysiological model of problem-solving", the following strategies would be employed according to the stages suggested by Wallas (1926):

The preparatory stage. In this stage, which corresponds to Deikman's (1971) "action mode", a general state of relaxation as indicated by a high alpha or low beta EEG pattern (10 - 12 Hz) would be brought about. Although there is some research which suggests that a high level of arousal - which

is reflected by the 40 Hz beta EEG pattern-- (Sheer, 1975) and is accompanied by varying degrees of anxiety (Brown, 1977) facilitates problem-solving, it has been substantially concluded that there is a generally negative correlation between problem-solving ability and measured (utilizing various physiological indices such as the EEG) or repeated anxiety states (Bodi, 1969; Carlson, 1969; Frost, 1969; Harper, 1971; Johnson, 1970; Kastenbaum, 1970; Klein, 1969; Mann, 1968; Proger, 1972; Pulvino, 1972; Mandler, 1952; Sarason, 1960; Sheldon, 1970). In fact, Jacobson (1973) has stated that emotional discomfort--in the form of anxiety--is a source of distraction from the learning process with respect to both recall (convergent) and creativity (divergent). In this preparatory stage a conscious effort to analyze the problem would be encouraged, through identification of the variables involved in the problem. The individual would be required to delineate the goals and objectives of the problem-solving exercise.

The incubation stage. This stage is similar to Deikman's (1971)"receptive stage." Attention would be focused inwardly, and a deeper state of relaxation would be attained. This deeper state of relaxation would be determined by the elicitation of the alpha (8.0 - 13.5 Hz) EEG pattern. The individual would be instructed to produce as many solutions to the given problem without any evaluation as to their merit or practicality.

The illumination stage. The illumination stage also corresponds to Deikman's (1971) receptive mode, and would be characterized by a very deep

state of relaxation reflected in the 5.5 - 7.5 Hz theta EEG pattern. No conscious effort to focus on the problem would be attempted. Thoughts would be allowed to flow freely.

Verification. The individual would shift his/her focus of attention externally, and would again enter Deikman's "action mode." A normal state of alertness would be attained, which would be indicated by the high alpha or low beta (10 - 12 Hz) EEG pattern. Evaluation of the products with respect to practicality and adherence to the initial goals of the problem-solving exercise would take place at this stage. Of course the amount of time spent at each stage and the sequencing of stages would be determined by the nature of the task and the characteristics of the individual.

Educational Applications of the Psychophysiological Model

Through the application of systematic relaxation techniques directed by psychophysiological research regarding cognitive and affective functioning, optimal learning and problem-solving states could be facilitated. As previously mentioned, individual student profiles could be developed concerning the student's physiologically measured preferred learning styles. The physiological states associated with the student's optimal observable performance on directly school-relevant learning or problem-solving tasks could be monitored and recorded for the purpose of ascertaining the most advantageous learning styles and expedient pedagogical techniques for the student. These physiological correlates might be expressed in EEG patterns for cognitive styles (left, right or integrated hemispheric processing). Affective or

subjective states (action or receptive modes) could also be determined by the EEG pattern frequency (theta, alpha and beta states), the electromyogram (EMG), a graphic recording of skeletal muscle states associated with relaxation, or the Galvanic Skin Reponse (GSR), the measure of skin conductivity for minute electrical currents based on skin moisture related to varying states of relaxation (Brown, 1977).

This idiographic profile would be similar in purpose to the psychometrically derived learning profiles that are currently utilized for diagnostic-prescriptive academic programming. For example, if it were ascertained that a right-handed, 12-year-old female's preferred learning style involved a predominantly left hemispheric (verbal) processing mode for spatial tasks under a more "receptive mode" (relaxed environment), the recommendations for this student in the area of physics might be as follows: this student should be provided with predominantly verbal cues (emphasizing reading over laboratory work) when learning physics, as well as the most relaxed classroom environment possible. Thus, through these psychophysiological learning profiles a more accurate picture of the learning "topography" could be provided because the influence of certain subject variables associated with conventional testing (test anxiety, attitude, ethnic and cultural background, meta learning skills) would be lessened or at least would be given more accurate weighting. With more precise knowledge of the student's learning strengths and weaknesses, a closer match between learning styles and methods of instruction could be arrived at. Therefore, the student's learning

potential could be more fully actualized. Furthermore, psychophysiologically determined profiles of the most successful individuals in particular cognitive or affective skill areas could be provided for replication by others just as observable behavioral patterns of the most renowned musicians, artists and athletes have been emulated for centuries by aspiring novices. A psychophysiological pattern determined to best facilitate learning or problem-solving might be practiced just as a sonata is practiced to obtain mastery of the piano. This type of "practice" would involve what Wallas (1926) termed the "self-training of one's natural thought processes" (p. 79). If the creative or problem-solving process could be operationally defined according to quantifiable physiological parameters, perhaps this process could be utilized within the framework of creativity training models which are in use today (e.g., "brainstorming" (Osborn, 1963; Parnes, 1962), "the Mindspring Theory" (Prince, 1976), and "synectics" (Gordon, 1961) to greatly increase the chances of generating solutions to heretofore unresolved problems.

Summary and Implications

Despite the fact that information about the functional organization of the cerebral hemispheres has been collected for over a century, the advent of non-intrusive, psychophysiological methods of investigation (EEG, dichotic listening tasks, visual field and saccadic eye movement observation) has greatly accelerated the understanding of the "bifunctional brain" (Ornstein, 1978). A review of representative studies and theoretical literature on hemispheric

functioning suggests the following divisions of function between the left and right hemispheres: The majority of verbal processing takes place in the left hemisphere for right-handed individuals over 10 years of age. For left-handed adults and children approximately five years of age or under, language processing is more equally divided between the hemispheres. The right hemisphere is more involved with the interpretation and retention of complex nonverbal visual and auditory patterns such as the recognition of facial features or recall of melodic patterns. The left hemispheric processing mode plays a predominant role in education, as the traditional "3 R's" (reading, writing and arithmetic), or "Basic Skills" are generally processed in the left hemisphere. The right hemisphere is primarily involved in processing the "artistic subjects" (music, art, dance) and physical education. The cognitive styles that are best described as logical, sequential and convergent are generally considered to be in the realm of the left hemisphere, whereas the right hemisphere is theorized to be more adroit at processing tasks that require deductive, simultaneous and divergent cognitive styles. The right hemisphere appears to be relatively more involved with affective responses than the left hemisphere. Emotional responses which result from aesthetic evaluation or perceptions are hypothesized to be products of the right hemisphere. Affective responses associated with qualitative judgments concerning the logical order or consistency of the information being processed are thought to be the psychological manifestations of left hemispheric processing.

Although the brain is "bifunctional", as substantiated by research on left and right hemispheric information processing styles and capacities, the most productive and creative intellectual functioning is theorized to occur when there is cooperation between hemispheres. The terms "cognitive emotion" (Scheffler, 1976) or the "inventive mode" (Samples, 1975) in essence, reflect the need for complementary yet different (Crinella, Beck & Robinson, 1971) hemispheric processing. Although this integration of left and right hemisphere functioning is not typical of mental activity (Gazzaniga & Hillyard, 1971; Kamiya, 1969), this integrative mode can be encouraged and facilitated through exposure to appropriate learning experiences that require simultaneous processing from both hemispheres (e.g., to define as many words relating to feelings of brotherhood as possible encourages the use of both the left (defining words) and the right (relating to feelings) hemispheres). Early (before six or seven years of age) and excessive emphasis on the development of processing skills of one hemisphere to the neglect of the other can possibly lead to permanent cognitive (Passow, 1964; Kennels, 1976; Yakovlev, 1967) or affective (Crinella, Beck & Robinson, 1971) deficits.

It has been found that educational experiences that were specifically designed to enhance right hemispheric processing (problem-solving skills) also improved performance on tasks considered to involve left hemispheric functions (verbal tasks) (Moller & Parnes, 1972; Samples, 1975). The results of EEG studies suggest that performance on tasks calling upon primarily left hemi-

spheric (verbal) processing is improved when the right hemisphere is drawn into play (Kraft, 1976; Norman, 1977). That is, those subjects whose EEG patterns reflected both left and right hemispheric (integrated) involvement in the processing of verbal tasks performed the best on these tasks. Furthermore, it has been suggested that creative geniuses are most adroit at functioning in this integrated mode (Ghiselin, 1952; Gilchrist, 1970; Kraft, 1976; Norman, 1977). It has also been suggested that this integrative mode coincides with reports of actualization or peak experiences (Garrett, 1976; Maslow, 1962; Norman, 1977).

Through the use of the electroencephalogram (EEG)(the graphic recording of the measurement of the electrical potential associated with brain activity) (Hinsie & Campbell, 1960), some of the physiological correlates of cognitive and affective functioning are being identified. These findings concerning physiological correlates of mental activity are being utilized to establish "information processing models" which are amenable to scientific, empirical investigation. Reciprocal relationships between physiological and mental states have been incorporated into what Green (1971) has termed "the psychophysiological principle". Green, in the "psychophysiological principle" asserts that certain physiological measures vary predictably as a function of particular cognitive and affective states. Most importantly, those particular cognitive and affective states can be elicited by producing the physiological state associated with those cognitive and affective states. This conscious regulation of physiological states would be accomplished through systematic

relaxation training techniques such as Autogenic Training (Green, 1970) or Progressive Relaxation (Jacobson, 1973). It has been clearly demonstrated that specific physiological states (as indicated by EEG patterns) associated with particular cognitive and affective states can be consciously attained, and that the two states (psychological and physiological) will occur simultaneously (Green, Green & Walters, 1970; Honorton, Davidson & Bindler, 1972; Hord, Lubin & Johnson, 1975; Kamiya, 1962, 1967, 1968; Nowlis & Kamiya, 1970; Schwartz, Davidson & Pugash, 1976; Sittenfeld, 1970).

The results of research findings on hemispheric and psychophysiological correlates of information processing have been presented herein with Wallas' (1926) four-stage theory of creativity in order to develop the "psychophysiological model of problem-solving". In this proposed model, the physiological indices which appear to be closely associated with Wallas' four stages of creativity (preparation, incubation, illumination, verification) are presented in terms of empirically quantifiable physiological measures (EEG patterns). Therefore, the possibility of an operationally defined sequence for problem solving is posited as an outcome of the proposed model. It is further hypothesized that via systematic relaxation training techniques, conscious elicitation of the various physiological states associated with each of the problem-solving stages can be attained, and more effective problem-solving made possible. In addition, learning in general would be improved if the individual could alleviate inappropriate and debilitating anxiety which may be associated with certain learning experiences (test

anxiety, etc.) (Jacobson, 1973) through the mastery of relaxation techniques. This relaxation training could be incorporated into the physical education curricula. It is further hypothesized that this proposed "psychophysiological model of problem-solving" could be adapted to existing creativity training models, such as "brainstorming" (Parnes & Meadow, 1959) to ascertain physiological aspects of these training models, and thus perhaps more operationally define and increase the replicability of successful creativity training and problem-solving strategies.

Through the psychophysiological approach to ascertaining the student's optimal cognitive styles (as reflected by EEG patterns) and affective states (either by EEG or other empirical measures), more precise and individualized learning and problem-solving profiles could be constructed. This greater precision in developing learning profiles could be accomplished because the influence of subject variables such as test anxiety, attitudes and cultural background of the subject, etc. would be either mitigated or more accurately accounted for as the result of a more direct measure of these influences. The teaching strategies for each student could then be more accurately tailored to the student's profile in order to more fully maximize the student's learning and problem-solving abilities.

Psychophysiological profiles of the most effective learners or problem-solvers could be provided for replication by other individuals just as the observable performance of outstanding musicians or athletes are studied and

practiced by apprentices. Thus, the development of outstanding problem-solvers could be nurtured with the hope of increasing the chances of creative genius occurring.

Implications

Through the study of the psychophysiological aspects of cognitive and affective functioning, models of mental functioning are being constructed that are amenable to empirical investigation. By establishing the psychophysiological parameters of cognitive and affective functioning, it appears that the attempts to understand and enhance the intellective processes will be greatly advanced. Psychophysiological research conducted on the hypothesized reciprocal relationship between cognitive and affective states and associated physiological states strongly suggests that particular mental states can be elicited through application of systematic relaxation techniques. Thus, through the psychophysiological methods of investigation into the underlying dynamics of cognitive and affective functioning, the student may in fact "be taught about the nature of his own intellectual resources, so that he may gain more control over them" as discussed by Guilford (1975).

The implications of psychophysiological research on learning and problem-solving for education are numerous. The following represent the most salient: 1) the most effective learning style of the student appears to be influenced to a considerable degree by each student's neurological processes, which are dependent on the genetic, age, and sex characteristics of the child. These students' neurologically based learning styles require that the process by

which the material is imparted be adjusted to the student's individual learning style. 2) A much greater emphasis on aesthetic and affective education is needed. Development of aesthetic and affective areas has perhaps been neglected in education because growth in these areas cannot be easily quantified, and a dichotomy between rational thought and feelings was believed to exist. Psychophysiological research indicates that this dichotomy does not exist, and that optimal learning and problem-solving require an integration of the cognitive-affective, logical-intuitive functions of the individual. 3) The student's learning experiences should be guided to more fully utilize the intuitive approach to problem-solving. The student should also be encouraged to realize that the intuitive approach is a legitimate, albeit underused aspect of intellective functioning. Many of our most creative scientists attribute their accomplishments and discoveries to the judicious use of intuition. The intuitive mode is an important aspect of research skills. 4) A relaxed classroom environment should be encouraged. When a student is called upon to respond to a question, the quality and depth of the answer rather than the speed of the answer should be valued. (A Stanford University study found that the average length of time that a student is allowed to provide a response ranges from two to three seconds (Brandwein & Ornstein, 1977). A tense, over-competitive classroom environment will inhibit student participation, learning, and creativity according to findings of studies on learning and anxiety. 5) Each student should be provided with the skills to

regulate his/her own physiological states to enhance learning, problem-solving abilities, and general social and emotional development. Relaxation techniques could be incorporated into physical education classes.

Through psychophysiological research concerning intellectual functioning the opportunity for each individual to discover the "fullness of his own gifts" (Bronowski, 1973) may be increased. The hope for the future depends upon our understanding and nurturance of the processes that underlie creative genius. As educators, the more precision we can obtain concerning the processes and facilitation of learning and creativity, the greater will be the chance of each student's potential being actualized. For, it has been said: "The raw materials are ours, the expertise is with us and the time is ripe: we will be architects to the brilliant and productive people of the future" (Khatena, 1976, p. 87).

Table 1

Summary of Representative Studies on the

Relationship Between Cognitive Functions and Hemispheric Processing

Dependent Variables		Independent Variables	N	Investigators	Year
Left Hemisphere	Right Hemisphere				
VERBAL					
Verbal (Auditory-Receptive)		Diagnosed Lesions	150	Paglioni et al.	1969
Verbal (Memory)		Diagnosed Lesions	125	deRenzi	1975
Verbal (53% of Left-Handers)	Verbal (47% of Left-Handers)	Diagnosed Lesions	123	Goodglass & Quadfasel	1954
Verbal (Verbal Scale IQ)		Diagnosed Lesions	26	Vega & Parsons	1969
Verbal (Memory)		Diagnosed Lesions	10	Springer & Eisenson	1976
Verbal (Memory)		Diagnosed Lesions	9	Hao	1974
	Limited Verbal With Sufficient Time	Diagnosed Lesions	1	Butler	1968
Verbal (General)		ECT	100	Fromholt et al.	1975
Verbal (General)		ECT	24	Fleminger & Bunce	1975
Verbal (Memory)		ECT	20	deElia et al.	1976
Verbal (General)		EEG	82	Cabral & Scott	1975

Dependent Variables		Independent Variables	N	Investigators	Year
Left Hemisphere	Right Hemisphere				
	VERBAL				
Verbal (Verbal Scale IQ)		EEG	19	Gruzelier & Hammond	1976
Verbal (General)		EEG	18	Kraft	1976
Verbal (General)		EEG	10	Ornstein	1978
Verbal (General)		EEG	4	McKee et al.	1973
Verbal (General)		EEG	1	Kennels	1957
Verbal (General)		Visual Field	96	Hellige & Cox	1976
Verbal (General)		Lobectomy (L.H.)	50	Cherlow & Serafetinidis	1975
Verbal (Memory)		Lobectomy (L.H.)	15	Maksymczuk	1973
Verbal (Auditory-Receptive)		Dichotic Listening Task	20	Kimura	1967
Verbal (General)		Commissurotomy	12	Janes	1976
Speech		Hemispherectomy (L.H.)	1	Burkland & Smith	1977
Verbal (General)		Hemispherectomy (L.H.)	1	Curry	1968
Speech		Hemispherectomy (L.H.)	1	Zellinger	1935
		Hemispherectomy (L.H.)	1	Basser	1962

Dependent Variables			Independent Variables	N	Investigators	Year
Left Hemisphere		Right Hemisphere				
	NONVERBAL VISUAL	Facial Recognition	Diagnosed Lesions	60	Muller	1973
		Facial Recognition	Handedness	55	Crinella et al.	1971
		Visuo-Spatial	EEG	50	Newton	1975
		Memory	Visual Field	40	Hines et al.	1976
		Facial Recognition	Visual Field	25	Compton & Bradshaw	1976
		Memory - Spatial	EEG	20	Schwartz et al.	1976
		Facial Recognition	Diagnosed Lesions	10	Hillard	1973
	NONVERBAL AUDITORY	Musical Patterns	Diagnosed Lesions	150	Paglioni et al.	1969
		Musical Patterns	Diagnosed Lesions	25	Vega & Parsons	1969
		Musical Patterns	Diagnosed Lesions	1	Luria	1969
		Musical Patterns	Dichotic Listening Task		Kimura	1961

Dependent Variables		Independent Variables			
Left Hemisphere	Right Hemisphere				
COGNITIVE STYLES					
Logical	Nonsequential	Visual Field	82	Lawson	1975
	Divergent	Handedness	36	Williams	1976
	Divergent	Eye Movement	54	Harnad	1972
Reality Testing		EEG	19	Gruzelier & Hammond	1972
Analytic		Left Front Lobectomy	15	Maksymczuk	1973
Logical		EEG	18	Kraft	1976
EDUCATIONAL CONTENT					
Reading		EEG	50	Newton	1975
Technical (Scientific) Reading	Some involvement of R.H. in non-technical "story" reading	EEG	10	Ornstein	1978
Math		Visual Field	10	Day	1964
Writing		Hemispherectomy	1	Smith	1972
DOMINANCE					
Physically Larger		Post-Mortem Examination	100	Geschwind	1970
Greater Activity		EEG	166	Darvaj & Smyk	1972

Table 2

Review of Literature Related to the

Functional Organization of the Hemispheres[1]

VERBAL

Left Hemisphere	Right Hemisphere	Investigators	Year
Writing		Brandwein & Ornstein	1977
Verbal		Olson	1977
Language (Age 5)		Calearo	1975
Verbal		Dumas	1975
Language		Epinas	1975
Language (Age 5)		Harris	1975
Verbal - numerical		Callaway	1975
Verbal - numerical		Doyle	1974
Speech		Nebes	1974
Language (Age 5)		Pinous	1974
Speech		Sperry	1974
Speech		Eccles	1974
Verbal - numerical		McKee	1973
Verbal - numerical		Morgan	1973

[1] Functional organization, in essence, is where certain processing functions (e.g., language processing) are hypothesized to be localized in the cerebral hemispheres.

VERBAL

Left Hemisphere	Right Hemisphere	Investigators	Year
Writing		Luria	1970
Language		Kimura	1967
Verbal (VSIQ)		Guertin et al.	1966
Language (98%)		Penfield & Roberts	1959
	Limited Language (Pitch Perception)	Van Lanker	1975
	Metaphoric Expression	May	1977
	Limited Language	Geschwind	1970
	Metaphoric Expression	Samples	1975
	Metaphoric Expression	Ornstein	1972
	Limited Verbal (with adequate time)	Gazzaniga & Hillyard	1971
	Limited Verbal	Nebes & Sperry	1971
	Limited Verbal	Lenneberg	1967
	Limited Verbal	Luria	1966
	Limited Verbal (with adequate time)	Bogen & Gazzaniga	1965
	Limited Verbal	Weisenberg & McBride	1935
	Language	Jackson	1866

NONVERBAL
(VISUAL)

Left Hemisphere	Right Hemisphere	Investigators	Year
	Spatial	Brandwein & Ornstein	1977
	Spatial	Olson	1977
	Spatial	Hunter	1976
	Spatial	Goyvaerts	1975
	Spatial - Males more adept	Harris	1975
	Spatial	Schwartz	1975
	Spatial	Dimond & Beaumont	1974
	Spatial	Kimura	1973
	Spatial	Milner	1971
	Spatial	Knox & Kimura	1970
	Spatial	Benton	1969
	Visual - Nonverbal Symbols	Zangwill	1961
	Visual - Nonverbal Symbols	Humphrey and Zangwill	1951

Left Hemisphere	Right Hemisphere	Investigators	
NONVERBAL (AUDITORY)			
	Music	Duffery	1976
	Music	Entus	1975
	Music	Molfese	1975
	Music	McKee	1973
NONVERBAL (SENSORY)			
	Tactile (Touch)	Epinas	1975
	Bodily Orientation	Hecaen	1975
	Bodily Orientation	Warrington & Rabin	1970
	Aesthetic	Hebb	1966
	Aesthetic	Hadamard	1945
COGNITIVE STYLES			
	Creative	Torrance	1978
Analytic		Brandwein & Ornstein	1977
Acquiring new habit patterns.		May	1977
Convergent, rational linear	Divergent, holistic	Perrone & Pulvino	1977

Left Hemisphere	Right Hemisphere	Investigators	Year
Convergent	Divergent	Bogen	1976
Logical		Dilling	1976
	Intuitive	Garrett	1976
Logical		Kraft	1976
	Approximate Knowledge	Prince	1976
Differentiated - Controlled		Epinas	1975
	Analogic - Divergent	Samples	1975
Sequential - Logical	Holistic	Papcun et al.	1974
Analytic		Sperry	1974
Analytic	Analogic	Salk	1973
	Intuitive	Rennels	1972
	Creative	Tart	1972
Sequential Temporal		Luria	1970
	Creative	Bogen	1969
Convergent		Wallach & Kogan	1965
Discrete	Diffuse	Semmes et al.	1960
Education of Relations	Education of Correlates	McFie & Piercy	1952

EDUCATIONAL CONTENT

Left Hemisphere	Right Hemisphere	Investigators	
Writing		Brandwein & Ornstein	1977
Algebra	Geometry	Hunter	1976
Reading/Math		Sperry	1974
Math		Nebes	1974
Writing		Luria	1970
Math		Day	1964

AFFECT

Positive	Negative	Dimond et al.	1976
	Negative	Janes	1976
	Affect in general	Ornstein	1972
Affect related to consistency	Affect related to aesthetics	Hebb	1966
Affect related to consistency.	Affect related to aesthetics	Hadamard	1945

Table 3

The Suggested Physiological Concomitants[1] of Cognitive-Affective[2] Functioning

EEG Pattern	Delta		Theta		Alpha		Beta	
Cycles per Second (Hz)	.5 - 3.0		3.5 - 7.5		8.0 - 13.5		14.0 - 40	
Hemisphere Involved	Right Hemisphere		Right Hemisphere		Right Hemisphere		Left Hemisphere	
	Cognitive Style	Affect	Cognitive Style	Affect	Cognitive Style	Affect	Cognitive Style	Affect
	Dreaming	Dreaming	Insights	Twilight	Receptive	Relaxed Wakefulness	Active	Anxiety
			Reverie	Drowsiness	Internal Focus	Peak Experience	External Focus	Apprehension
			Illumination		Field Independent		Field Dependent	
					Nonverbal		Verbal	
					Divergent		Convergent	
					Problem Finding		Problem Solving	
					Intuitive		Analytical	
					Aesthetic Discriminations		Logical Discriminations	

[1] The physiological concomitants as measured by the graphic record of electrical activity associated with mental functioning (electroencephalogram or EEG).

[2] Affect or those states of awareness associated with the particular physiological state.

Table 4

The Psychophysiological Model for Problem-Solving

Wallas' Stages	Deikman's Modes	Characteristic EEG Pattern	Hemisphere
Preparation	Active (Analysis of Problem)	beta (14 - 40 Hz)	Left
Incubation	Receptive (Suspension of Reality Testing)	alpha (8.0 - 13.5 Hz)	Right
Illumination	Receptive (Reverie, Visual Imagery, Free Flow of Thoughts)	theta (3.5 - 7.5 Hz)	Right
Verification	Active (Judgment of Solutions)	beta (14 - 40 Hz)	Left

Anastasi, Anne Psychological Testing. (3rd Ed.) London: The Macmillan Co., 1968

Barber, T. X., et al. (Eds.) Biofeedback and self-control. Chicago: Aldine, 1971.

Basser, L. S. Hemiplegia of early onset and the faculty of speech with special reference to the effects of hemispherectomy. Brain, 85, 427-460.

Benton, A. L. Disorders of spatial orientation. In P. J. Vinken & G. W. Bruyn (Eds.),Handbook of clinical neurology, (Vol. 3), Amsterdam: North Holland Publishing Company, 1969.

Bever, T. J., & Chiarello, R. J. Cerebral dominance in musicians and nonmusicians. Science, 1974, 183, 537-539.

Bodi, Elizabeth M. The effect of human relations training upon the academic achievement of pre and early adolescent children. Dissertation Abstracts International, 1970, 30 (4-A), 1340.

Bogen, J. E., & Gazzaniga, M. S. Cerebral commissurotomy in man: Minor hemisphere dominance for certain visuospatial functions. Journal of Neurosurgery, 1965, 23, 394-399.

Brandwein, P., & Ornstein, R. The duality of the mind. Instructor, January, 1977, pp. 54-58.

Brazier, Mary A.B. The electrical activity of the nervous system. Baltimore: The William & Wilkins Company, 1968.

Brown, J. W. The neural organization of language: Aphasia and lateralization. Brain and Language, October, 1976, 3(4), 482-494.

Budzynski, T. H. Some applications of biofeedback produced twilight states. Paper presented at the 1971 American Psychological Association Convention, Washington, D.C.

Budzynski, T. H., Stoyva, J. M., & Adler, C. S. The use of feedback-induced muscle relaxation in tension headache: A controlled-outcome study. Annual Meeting of the American Psychological Association, Miami Beach, Florida September 3 - 8, 1970 (b).

Buffery, A. W. H. Sex differences in the neuropsychological development of verbal and spatial skills. In D. J. Bakker & H. M. Knights (Eds.) The neuropsychology of learning disorders. Baltimore: University Park Press, 1976, pp. 187-205.

Burklund, C. W. Cerebral hemisphere function in the human: Fact versus tradition. In W.L. Smith (Ed.) Drugs, development and cerebral function. Springfield, Illinois: Charles C. Thomas, 1972, pp. 8-36.

Burkland, C. W., & Smith, A. Language and the cerebral hemispheres. Neurology, July, 1977, 27, 627-633.

Butler, S. H., & Glass, A. Asymmetrics in the electroencephalogram associated with cerebral dominance. Electroencephalography and Clinical Neurophysiology, 1974, 36, 481-491.

Cabral, R., & Scott, D. F. The degree of alpha asymmetry and its relation to handedness in neuropsychiatric referrals. Acta Neurologica Scandinavica, May, 1975, 51 (5), 380-384.

Cacha, B. Figural creativity, personality and peer nominations of pre-adolescents, The Gifted Child Quarterly, 1976, XX (2), 187-195.

Calearo, C. Verbal tests of central audition, Audiology, 1975, 14 (4), 300-311.

Callaway, E., & Harris, P. R. Coupling between cortical potentials from different areas. Science, 1974, 183, 873-875.

Carlson, J. Levels of cognitive functioning as related to anxiety. Journal of Experimental Education, 1969, 37 (4), 17-20.

Chadwick, J., & Mann, W. N. The medical works of Hippocrates. Oxford: Blackwell, 1950.

Cherlow, D. G., & Serafetinides, E. A. Speech and memory abilities in psychomotor epileptics. Cortex, March, 1976, 12 (1), 21-26.

Compton, A., & Bradshaw, J. L. Differential hemispheric mediation of nonverbal visual stimuli. Journal of Experimental Psychology: Human Perception and Performance, August, 1975, 104 (1), (3), 246-252.

Crinella, T. M., Beck, F. W., & Robinson, J. W. Unilateral dominance is not related to neuropsychological integrity. Child Development, December, 1971, 42, (6), pp. 2033-54.

Curry, F. W. A comparison of the performances of a right hemispherectomized subject and 25 normals on 4 dichotic listening tasks, Cortex, 1968, 4, 144-153.

Darvai, B., & Smyk, K. Interhemisphere asymmetry in electroencephalographic alpha-rhythm and the problem of cerebral hemisphere dominance. Voprosy Psykhologii, May, 1972, 18 (3), 149-154.

Davidson, R., & Krippner, S. Biofeedback research: The data and their implications. Biofeedback and Self-Control, 1971, p. 23-34.

Day, M. E. An eye-movement phenomenon relating to attention, thought and anxiety. Perceptual and Motor Skills, 1964, 19, 443-446.

Debono, E. The use of lateral thinking. Toronto: Holt Publishing Co., 1971.

Deikman, R. Bimodal consciousness. Biofeedback and Self Control, 1971, 58-73.

d'Elia, G., Lorentzson, S., Raotman, H., & Widepalm, K. Comparison of unilateral dominant and non-dominant ECT on verbal and nonverbal memory. Acta Psychiatrica Scandinavia, February, 1976, 53 (2), 85-94.

deRenzi, E., & Nichelli, P. Verbal and non-verbal short-term memory impairment following hemispheric damage. Cortex, December, 1975, 11 (4), 341-354.

DiCara, L. Learning in the autonomic nervous system. Scientific American, January, 1970.

Dimond, S. J., & Beaumont, J. G. Experimental studies of hemisphere function in normal and brain-damaged individuals. In S. J. Dimond & J. G. Beaumont (Eds.), Hemisphere functions of the human brain. London: Elek Science, 1974.

Dimond, S., Farrington, L., & Johnson, P. Differing emotional responses from right and left hemispheres. Nature, 1976, 261, 690-692.

Doyle, J.C., Ornstein, R., & Galin, D. Lateral specialization of cognitive mode: II. EEG frequency analysis. Psychophysiology, 1974, 11, 567-568.

Dumas, R., & Morgan, A. EEG asymmetry as a function of occupation, task, and task difficulty. Neuropsychologica, April, 1975, 13, (2), 219-228.

Eccles, J. C. The understanding of the brain. New York: McGraw-Hill Books, 1973.

Entus, A. K. Hemispheric asymmetry in processing of dichotically presented speech and nonspeech sounds by infants. Meeting of the Society for Research in Child Development, 1975, (Abstract).

Epinas, J. Neurophysiological aspects of laterality. Revue de Neuropsychiatrie Infantile et d'Hygiene Mentale de l'Enfance, January, 1975, 23, (1), 5-11.

Faglioni, P., Spinnler, H., & Vignolo, L. A. Contrasting behavior of right and left hemisphere-damaged patients on a discriminative and a semantic task of auditory recognition. Cortex, 1969, 5, 366-389.

Fleminger, J. J., & Bunce, L. Investigation of cerebral dominance in "left-handers" and "right-handers" using unilateral electroconvulsive therapy. Journal of Neurology, Neurosurgery and Psychiatry, June, 1975, 38 (6), 541-545.

Fromholt, P., Christensen, A. L., & Stromgren, L. The effects of unilateral and bilateral electroconvulsive therapy on memory. Acta Psychiatrica Scandinavica, 1973, 49 (4), 466-478.

Frost, B. Studies of anxiety and educational achievement. Revista Interamericana de Psicologia, 1969, 3 (2), 83-91

Foulkes, D. The psychology of sleep. New York: Scribners, 1966.

Foulkes, D., & Vogel, G. Mental activity at sleep onset. Journal of Abnormal Psychology, 1965, 70, 231-243.

Garrett, S. V. Putting our whole brain to use: A fresh look at the creative process. Journal of Creative Behavior, 1976, 10 (4), 239-249.

Gazzaniga, M. S. The split brain in man. Scientific American, 1967, 217 (2), 24-29.

Gazzaniga, M. S., & Hillyard, S. A. Language and speech capacity of the right hemisphere. Neuropsychologia, 1971, 9, 273-280.

Geschwind, N. Language and the brain. Readings from Scientific American: Recent Progress in Perception . San Francisco: W. H. Freeman & Company, 1979.

Getzels, J. W., & Jackson, P. W., Creativity and intelligence. New York: John Wiley & Sons, Inc., 1962.

Gilchrist, M., & Tart, R. Creative attitudes and creative productivity: A comparison of two aspects of creativity among students. Journal of Educational Psychology, April, 1970, 62, 136-143.

Goodglass, H., & Quadfasel, F. A. Language laterality in left-handed aphasics. Brain, 1954, LXVII, 521-548.

Gowan, J. C. Trance, art and creativity. Journal of Creative Behavior, 1975 9, 1-11.

Gowan, J. C. The development of the creative individual. San Diego: Robert Knapp, 1972.

Goyvaerts, Monique Recent advances in language acquisition. Communication and Cognition, 1975, 8 (1), 45-67.

Green, E. E., Green, A. M., & Walters, E. D. Voluntary control of internal states: psychological and physiological. Journal of Transpersonal Psychology, 1970, 2, 1-26.

Green, E. E., Walters, E. D., Green, A. M., & Murphy, G. Feedback technique for deep relaxation. Psychophysiology, 1969, 6, 371-377.

Gruzelier, J., & Hammond, N. Schizophrenia: A dominant hemisphere temporal-limbic disorder? Research Communications in Psychology, Psychiatry and Behavior, 1976, 1 (1), 33-72.

Guertin, W. H., Ladd, C. E., Frank, G.H., Rabin, A. I., & Hiester, D. S. Research with the Wechsler Intelligence Scales for adults, 1960-1965. Psychological Bulletin, 1966, 66, 385-509.

Guilford, J. P. Varieties of creative giftedness: Their measurement and development. The Gifted Child Quarterly, 1975, XIX, (2).

Guilford, J. P. Intelligence, creativity and their educational implications, San Diego, California: Knapp, 1968.

Hac, P. M. Short-term memory in patients with left (dominant) frontal lobe lesions. Psychologia: An International Journal of Psychology in the Orient, December 1974, 17 (4), 186-192.

Hadamard, J. The psychology of invention in the mathematical field. Princeton: Princeton University Press, 1945.

Harper, F. B. Specific anxiety theory and the Mandler-Sarason Test Anxiety questionnaire. Educational and Psychological Measurement, Autumn - winter, 1971, 31.

Harnad, S. R. Creativity, lateral saccades and the nondominant hemisphere. Perceptual and Motor Skills, 1972, 34, 653-654.

Harris, L. J. Functional specialization of the cerebral hemispheres in infants and children: New experimental and clinical evidence. Paper presented at the Biennial Meeting of the Society for Research in Child Development, Denver, Colorado, April 13, 1975.

Hart, J. T. Autocontrol of EEG alpha. Paper presented at the Seventh Annual Meeting of the Society for Psychophysiological Research, San Diego, October 20-22, 1967.

Hassett, J., & Schwartz, G. E. Relationships between heart rate and occipital alpha: A biofeedback approach. Psychophysiology, 1975, 12, 228 (Abstract).

Hebb, D. O. A textbook of psychology. Philadelphia: Saunders, 1966.

Hecaen, H. Functional hemispheric asymmetry and behavior. Social Science Information, December 1973, 12 (6), 7-23.

Hellas, M., & Gaier, E. L. Identification of creativity: the individual. Psychological Bulletin, 1970, 73 (1), 55-73.

Hellige, J. B., & Cox, P. J. Effects of concurrent verbal memory on recognition of stimuli from the left and right visual fields. Journal of Experimental Psychology: Human Perception & Performance, May, 1976, 2 (2), 210-221.

Hilliard, R. D. Hemispheric laterality effects on a facial recognition task in normal subjects. Cortex, September 1973, 9 (3), 246-258.

Hines, D., Sutker, L. W., & Satz, P. A. Recall of letters from the left and right visual half-fields under unilateral and bilateral presentation. Perceptual and Motor Skills, 1976, 42 (2), 531-539.

Hinsie, L. E., & Campbell, R. J. Psychiatric Dictionary, New York; Oxford University Press, 1960.

Honorton, C., Davidson, R. J., & Bindler, P. Shifts in subjective state associated with feedback-augmented EEG alpha. Biofeedback and Self-Control, 1972.

Hord, D. J., Naitoh, P., Johnson, L. C., & Tracy, M. L. Intra-hemispheric phase relationships during self-regulated alpha activity. Biofeedback & Self-Control, 1972.

Hord, D. J., Tracy, M. L., Lubin, A., & Johnson, L. C. Effect of self-enhanced EEG alpha on performance and mood after two nights of sleep loss. Psychophysiology, 12 (5), 1975, 585-590.

Humphrey, M. E., & Zangwill, O. L. Cessation of dreaming after brain injury. Journal of Neurolog. Neurosurg. Psychiat., 1951, 14, 322-325.

Hunter, M. Right-brained kids in left-brained schools. Today's Education, November - December 1976, 45-48.

Jackson, J. Right cerebral lesion of aphasia. Medical Times Gazette, 1866,(2), 210.

Jacobson, E. Electrophysiology of mental activities. American Journal of Psychology, October, 1932, 44, 677-694.

Jacobson, E. Teaching and learning new methods for old arts. U.S. National Foundation for Progressive Relaxation, 1973.

Janes, J. The origin of consciousness in the breakdown of the bicameral mind. Boston: Houghton-Mifflin Co., 1976.

Johnson, D. M. Systematic introduction to the psychology of thinking. New York: Harper, 1972.

Johnson, G. L. An experimental study of the effects of three modes of test administration on the reading achievement of fifth graders grouped according to test anxiety. Dissertation Abstracts International, 1969, 30 (9-A), 3789-3790.

Kamiya, J. Conditioned discrimination of the EEG alpha rhythm in humans. Paper presented at the Meeting of the Western Psychological Association, San Francisco, April, 1962.

Kamiya, J. EEG operant conditioning and the study of states of consciousness. In D. X. Freedman, Laboratory studies of altered psychological states, Symposium at the American Psychological Association, Washington, D.C. September 4, 1967.

Kamiya, J. Operant control of the EEG alpha rhythm and some of its reported effects on consciousness. In C. T. Tart (Ed.) Altered states of consciousness, New York: John Wiley & Sons, 1969.

Kasamatsu, A., & Hirai, T. Science of zazen. Psychologia, 1963, 6, 89-91.

Khatena, J. Educating the gifted child: Challenge and response in the U.S.A. Gifted Child quarterly, 1976, XX, (1), 76-90.

Kimmel, H. D. Instrumental conditioning of autonomically mediated behavior. Psychological Bulletin, 1967, 67, 335-345.

Kimura, D. Functional asymmetry of the human brain in dichotic listening. Cortex, 1967, 3, 163-178.

Kimura, D. The asymmetry of the human brain. In Recent Progress in Perception, March, 1973, 246-254.

Kinsbourne, M., & Smith, W. L. Hemispheric disconnection and cerebral function. Springfield, Illinois: Charles C. Thomas, 1974.

Knox, C., & Kimura, D. Cerebral processing of nonverbal sounds in boys and girls. Neuropsychologia, 1970, 8, 227-237.

Kraft, R. H. An EEG study: Hemispheric brain functioning of six to eight year-old children during Piagetian and curriculum tasks with variation in presentation mode. Ph.D. Dissertation, the Ohio State University, 1976.

Laski, M. Ecstasy, Bloomington Indiana: Indiana University Press, 1962.

Lawson, A. E., & Wollman, W. T. Hemispheric dominance, conservation reasoning and the dominant eye. National Science Foundation, Washington D.C., November, 1975.

Lenneberg, E. Biological foundations of language. New York: Wiley, 1967.

Levy, J. Possible basis for the evolution of lateral specialization of the human brain. Nature, 1969, 224, 615-615.

Lindsley, D. B. Attention, consciousness, sleep and wakefulness. In J. Field (Ed.) Handbook of physiology, Section I: Neurophysiology, Vol. III, Washington D.C. American Physiological Society, 1960.

Luria, A. R. The functional organization of the brain. Readings from Scientific American: Recent progress in perception. San Francisco: W. H. Freeman & Co., 1970.

Luthe, W., Jus, A., & Geissman, P. Autogenic state and autogenic shift: psychophysiologic and neurophysiologic aspects. Acta Psychother., 1963, 11, 1-13.

Lynch, J. J., & Paskewitz, D. A. On the mechanisms of the feedback control of human brain wave activity. Journal of Nervous and Mental Disease, 1971.

Mackinnon, D. Creativity and transliminal experience. Unpublished paper given at the American Psychological Assocation Convention in Los Angeles, California, 1964.

Maksymczuk, A. Disorders in remembering the structure of serial material with individuals following a unilateral temporal lobectomy. Studia Psychologiczne, 1973, 12, 127-165.

Mandler, G., & Sarason, S. A study of anxiety and learning. Journal of Abnormal and Social Psychology, 1952, 47, 166-173.

Mann, L., Taylor, R., & Barton, R. Test anxiety and defensiveness against admission of text anxiety induced by frequent testing. Psychological Reports, 1968, 23, 1283-86.

Maslow, A. H. Towards a psychology of being. Princeton: D. Van Nostrand, 1962.

May, R. Freedom, determinism and the future. Psychology, April, 1977, 6-9.

McFie, J., & Piercy, M. F. Intellectual impairment with localized cerebral lesions. Brain, 1952, 75, 292-311.

McGuinness, D., & Pribram, K. Male, female perceptual differences: What they imply. Brain/Mind Bulletin, February, 1978, p. 3.

McKee, G., Humphrey, B., & McAdam, D. W. Scaled lateralization of alpha activity during linguistic and musical tasks. Psychophysiology, 1973, 10, 441-443.

McKellar, P., & Simpson, L. Between wakefulness and sleep. British Journal of Psychology, 1954, 45, 266-276.

Miller, N. E. Learning of visceral and glandular responses. Science, 1969a, 163, 434-445.

Milner, B. Interhemispheric differences and psychological processes. British Medical Bulletin, 1971, 27, 272-277.

Milner, B. Psychological defects produced by temporal lobe excision. Res. Publ. Assn. Nerv. Ment. Dis., 1958, 36, 244-257.

Molfese, D. L., Freeman, R. B. Jr., & Palermo, D. S. The ontogeny of brain lateralization for speech and nonspeech stimuli. Brain and Language, 1975, 2, 356-368.

Morgan, A. H., McDonald, P. J., & MacDonald, H. Differences in bilateral alpha activity as a function of experimental task, with a note on lateral eye movements and hypnotizability. Neuropsychologia, 1971, 9, 459-469.

Moscovitch, M., Scullion, D., & Christie, D. Early versus late stages of processing and their relation to functional hemispheric asymmetries in face recognition. Journal of Experimental Psychology: Human Perception and Performance, August, 1976, 2 (3), 401-416.

Mulholland, T. B. Can you really turn on with alpha? Paper presented at a meeting of the Massachusetts Psychological Association, Boston College, May 7, 1977.

Mulholland, T. B., & Runnals, S. A stimulus-brain feedback system for evaluation of alertness. Journal of Psychology, 1962a, 54, 69-85.

Muller, E. On the objectivization of the symptom impaired facial recognition: An experimental psychological study of psychiatric-neurological groups of patients. Zeitschrift fur Klinische Psychologie, 1973, 2 (2), 126-144.

Murphy, G. Human potentialities. New York: Basic Books, 1958.

Nebes, R. D. Hemispheric specialization in commissurotomized man. Psychological Bulletin, January, 1974, 81, (1).

Nebes, R. D., & Sperry, R. W. Hemispheric deconnection syndrome with cerebral birth injury in the dominant arm area. Neuropsychologia, 1971, 9, 247-259.

Newton, M. A. A neuro-psychological investigation into dyslexia. Paper presented at the International Federation of Learning Disabilities (Second International Scientific Conference, Brussels, Belgium, January 3-7, 1975.

Noller, R. B., & Parnes, S. J. The creative studies project, part one - the development. The Journal of Creative Behavior, 1972, 6, (1), 11-22.

Norman, D. EEG patterns and reported insight states. Brain/Mind Bulletin, spring, 1977, 2 (13).

Nowlis, D. P., & Kamiya, J. The control of electroencephalographic alpha rhythms through auditory feedback and associated mental activities. Psychophysiology, 1970, 6, (4), 476-484.

Olson, M. E. Visual field usage as an indicator of right or left hemispheric information processing in gifted students. Gifted Child Quarterly, 1977, XXI (1), 116-120.

Ornstein, R. E. The psychology of consciousness. New York: W. H. Freeman & Co., 1972.

Osborn, A. F. Applied imagination. New York: Scribner's, 1963.

Papoun, C. Is the left hemisphere specialized for speech, language and/or something else. Journal of the Acoustical Society of America, 55, (2) February, 1974.

Parnes, S. J., & Harding, H. F. Do you really understand brainstorming? In S. J. Parnes & H. F. Harding (Eds.), A sourcebook for creative thinking. New York: Scribner's, 1962, 283-290.

Paskewitz, D., Lynch, J. J., Orne, M. T., & Castello, J. The feedback control of alpha activity: Conditioning or disinhibition. Psychophysiology, 1970, 6, 637-638.

Passow, A. H. The nature and needs of the disadvantaged. In P. Witty (Ed.) The sixty-sixth yearbook of the National Society for the Study of Education. Chicago: University of Chicago Press, 1967, 1-39.

Penfield, W., & Roberts, L. Speech and brain mechanisms. Princeton: Princeton University Press, 1959.

Perrone, P., & Pulvino, C. J. New directions in the guidance of the gifted and talented. Gifted Child Quarterly, 1977, XXI, (3), 326-335.

Pincus, J., & Tucker, G. Organic brain syndromes. Oxford: University Press, Inc., 1974.

Prince, G. M. The mindspring theory: A new development from synectics research. The Journal of Creative Behavior, 1976, 9, 159-87.

Proger, B. B. The relationship between four testing programs and resultant achievement and test anxiety levels of high and low previous achievement on 6th grade arithmetic studies. Dissertation Abstracts International, 1969, 28 (11-A), 3880.

Pulvino, C. J., & Hansen, J. C. Relevance of needs and "press" to anxiety, alienation and G.P.A. Journal of Experimental Education, 1972, 40, (3).

Rather, L. J. Mind and body in eighteenth-century medicine: A study based on Jerome Gaub's De regimine mentis. Berkeley: University of California Press, 1965.

Rennels, M. R. Cerebral symmetry: An urgen concern for education. Phi Delta Kappan, 57 (7), March, 1976, 471-472.

Salamon, I., & Post, J. Alpha blocking and schizophrenia. Archives of General Psychiatry, 1965, 13, 367-74.

Salk, J. The survival of the wisest. New York: Harper & Row, 1973.

Samples, R. Educating for both sides of the human mind. The Science Teacher, 197[illegible]. 42, (1), 21-23.

Sarason, S., Hill, K., & Zimbardo, J. A longitudinal study of the relation of test anxiety to performance on intelligence and achievement tests. Monographs of the Society for Research in Child Development, 1964, 29 (7 whole No. 98).

Scheffler, I. In praise of the cognitive emotions. Paper presented at annual Meeting of the American Psychiatric Association. Brooklyn College: Brooklyn, New York, 1976.

Schultz, J., & Luthe, W. Autogenic training: A psychophysiologic approach in psychotherapy. New York: Grune & Stratton, Inc., 1959.

Schwartz, G. E. Biofeedback, self-regulation, and the patterning of physiological processes. American Scientist, 1975, 63, 314-324.

Schwartz, G. E., Davidson, R. J., & Pugash, E. Voluntary control of patterns of EEG parietal asymmetry: cognitive concomitants. Psychophysiology November, 1976, 13, (6), 498-504.

Semmes, J., Weinstein, S., Ghent, L., & Teuber, H. L. Somatosensory changes after penetrating brain wounds in man. Cambridge, Massachusetts: Harvard University Press, 1960.

Shankweiler, D. Effects of temporal-lobe damage on perception of dichotically presented melodies. Journal of Comparative and Physiological Psychology, 1966, 62, 115-119.

Sheer, D. E. Electrophysiological correlates of memory consolidation. In A. Ungar (Ed.) Molecular mechanisms in memory and learning. New York: Plenum Press, 1970, p. 177.

Sheer, D. E. Neurobiology of memory storage processes. winter Conference on Brain Research, Vail, Colorado, 1972.

Sheer, D. E. Biofeedback training of 40 Hz EEG and behavior. In N. Bruch & L. Altschuler (Eds.) Behavior and brain electrical activity. Plenum Publishing Corp., 1975.

Sittenfeld, P. The control of the EEG theta rhythm. Biofeedback & Self-Control, 1972.

Smith, A. Dominant and nondominant hemispherectomy. In W. L. Smith (Ed.) Drugs, development and cerebral function. Springfield, Illinois: Charles, C. Thomas, 1972.

Sperry, R. W. Messages from the laboratory. Engineering and Science, January, 1974.

Springer, S. P., & Eisenson, J. Hemispheric specialization for speech in language-disordered children. Neuropsychologia, 1977, 15, 287-294.

Stoyva, J. M., & Kamiya, J. Electrophysiological studies of dreaming as the prototype of a new strategy in the study of consciousness. Psychological Review, 1968, 75, 192-205.

Tannenbaum, A. J. Meta learning. Presented at seminar - Nature and Needs of the Gifted, Teachers College, Columbia University, October, 1977.

Tart, C. T. Altered states of consciousness. Garden City, New York: Doubleday, 1972.

Taylor, R. Computers and hemispheric functioning. Presented at Seminar, Teachers College, Columbia University, New York, New York, February, 1970.

Thurstone, L. L. Implications of factor analysis. American Psychologist, 1948, 3, 402-428.

Torrance, E. P. Guiding creative talent. Englewood Cliffs, New Jersey: Prentice Hall, 1962.

Torrance, E. P., & Reynolds, C. R. Images of the future of gifted adolescents: Effects of alientation and specialized cerebral function. The Gifted Child Quarterly, 1978, XXII, (1), 40-54.

Torrance, E. P., Reynolds, C. R., Riegel, T., & Ball, O. Your style of learning: An r/l test. The Gifted Child Quarterly, 1977, XXI, (4), 563-585.

Van Lancker, D. Heterogeneity in language and speech: neurolinguistic studies. Working Papers in Phonetics, April, 1975, 29.

Vega, A. J., & Parsons, O. A. Relationship between sensory-motor deficits and WAIS verbal and performance scores in unilateral brain damage. Cortex, 1969, 5.

Vernon, P. E. Creativity. New York: Penguin Books, 1976.

Walkup, L. E. Creativity in science through visualization. Perceptual Motor Skills, 1965, 21, 35-41.

Wallach, M. A., & Kogan, N. Modes of thinking in young children. New York: Holt Rinehart & Winston, 1965.

Warrington, E. K., & Rabin, P. Perceptual matching in patients with cerebral lesions. Neuropsychologia, 1970, 8, 475-487.

Weisenberg, T., & McBride, K. E. Aphasia: a clinical and psychological study. New York: Commonwealth Fund, 1935.

Williams, B. B. The relationship between lateral dominance and divergent cognitive thought. Paper presented at the Annual Meeting of the Eastern Psychological Association, New York, New York, April 22-24, 1976.

Wolpe, J. W. The practice of behavior therapy. New York: Pergamon Press, 1969.

Wood, C. C., Goff, W. R., & Day, R. S. Auditory evoked potentials during speech perception. Science, 1971, 173, 1248-1251.

Woodruff, D. S. Relationships among EEG alpha frequency, reaction time, and age: A biofeedback study. Psychophysiology, 1975, 12(6), 673-689.

Yakovlev, P. I., & Lecours, A. R. The myelogenetic cycles of regional maturation of the brain. In A. Minkowski (Ed.) Regional development of the brain in early life. Philadelphia: Davis, 1967, 3-78.

Zaidel, D., & Sperry, R. W. Performance on the Raven's colored progressive matrices by subjects with cerebral commissurotomy. Cortex, 1973, 9, 33-39.

Zangwill, O. L. Speech and the minor hemisphere. Acta Neurologica Psychiat. Belgica, 1961, 67, 1013-1020.

Zellinger, R. Removal of left cerebral hemisphere. Arch. Neurology Psychiatry, 1935, 34, 1055-1064.

Addenda to References

1. (After Brazier, p. 21)

Brown, B. B. Stress and the Art of Biofeedback. New York: Harper & Row, 1977

2. (After Goyvaerts, p. 25)

Green, E., Green, A., & Walters, D. Outline of Verbal Procedure Used in Developing Voluntary Control of Internal States in Autogenic Feedback Training. Topeka, Kansas Research Department, The Menninger Foundation, 1977.

3. (After Getzels, p. 25)

Ghiselin, B. (Ed.). The Creative Process. New York: New American Library, 195

4. (After Olson, p. 32)

Ornstein, R. The split and the whole brain. In Nature, May, 1978, p. 76-83.

5. (After Wallach, p. 36)

Wallas, G. The Art of Thought. Jonathan Cape, 1926, pp. 79-96.

6. (After Bogen, pg. 21)

Branch, C. et al. Intracarotid sodium amytal for the lateralization of cerebral speech dominance. J. Neurosur. 21:399-465, 1965

7. (After Kraft, p.29)

Kupfermann, I. The Neural Sciences (Lecture Syllabus). New York. College of Physicians and Surgeons, Columbia University 1977 pp. 463-467

8.(After Williams. pg. 37)

Willis A. & Grossman, D. Medical Neurobiology, St. Louis. The C.V. Mosby Co. 1973 pp. 334-366.